THE UNITED STATES AIR FORCE

INSTALLATION RESTORATION PROGRAM

FINAL

MARBO ANNEX OPERABLE UNIT
RECORD OF DECISION

for

Andersen Air Force Base, Guam

May 1998

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13. ABSTRACT (Maximum 200 words)

This ROD summarizes the findings, documentation and public input leading up to the selection of remedial alternatives for soil and groundwater at the MARBO Annex Operable Unit at Andersen AFB, Guam. The selected remedial alternative for soil includes soil removal and disposal at three sites and soil cover at one site. The selected remedial alternative for groundwater includes natural attenuation with continued wellhead treatment at existing Air Force wells. The remedial alternatives were made public for comment from October 10, 1997 to November 10, 1997. A public meeting was held on October 24, 1997 to solicit verbal comments and concerns. Based on the public response, there were no significant objections to the selected remedial alternatives.

14. SUBJECT TERMS

MARBO Annex Record of Decision
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LIST OF ACRONYMS AND ABBREVIATIONS

AAFB	Andersen Air Force Base
AFB	Air Force Base
ARAR	Applicable or Relevant and Appropriate Requirements
bgs	Below Ground Surface
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation And Liability Act
CFR	Code of Federal Regulations
COC	Constituent of Concern
COPC	Constituent of Potential Concern
CRP	Community Relations Plan
cy	cubic yard
DCE	1,1-dichloroethene; 1,2-dichloroethene (also known as vinylidene chloride)
DDE	Dichlorodiphenyldichloroethylene
DEQPPM	Defense Environmental Quality Program Policy Memorandum
DOD	Department of Defense
DTSC	Department of Toxic Substances Control
EPC	Exposure Point Concentration
ESA	Endangered Species Act
ESE	Environmental Science and Engineering, Inc.
FFA	Federal Facility Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FS	Feasibility Study
ft/day	feet per day
GCA	Guam Code Annotated
GEPA	Guam Environmental Protection Agency
GPA	Guam Power Authority
gpm	gallons per minute
GWA	Guam Waterworks Authority
HARM	Hazard Assessment Rating Methodology
HI	Hazard Index
HSWA	Hazardous and Solid Waste Act
IRP	Installation Restoration Program
MARBO	Marianas/Bonins Command
MCL	Maximum Contaminant Level
MEK	Methylethylketone
mgd	million gallons per day
µg/L	micrograms per liter
mg/L	milligrams per liter
MIBK	Methyl isobutyl ketone
mph	miles per hour
msl	mean sea level
NCP	National Oil And Hazardous Substances Pollution Contingency Plan
NGL	Northern Guam Lens

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

NGLS	Northern Guam Lens Study
NPL	National Priorities List
NWS	National Weather Service
O&M	Operations and Maintenance
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethylene
P.L.	Public Law
POL	Petroleum, Oil, and Lubricants
PRG	Preliminary Remediation Goal
PUAG	Public Utility Agency of Guam
RAB	Restoration Advisory Board
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure Scenario
ROD	Record of Decision
RPM	Remedial Project Manager
RWQCB	Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TAG	Technical Assistance Grant
TBC	To Be Considered
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leachate Procedure
TMV	Toxicity, Mobility and Volume
TRC	Technical Review Committee
TSCA	Toxic Substances Control Act
UCL	Upper Confidence Limit
USAFOEHL	USAF Occupational and Health Environmental Laboratory
USAF	U.S. Air Force
USEPA	United States Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
USN	U.S. Navy
VOC	Volatile Organic Compound

1.0 DECLARATION

1.1 SITE NAME AND LOCATION

Andersen Air Force Base
MARBO Annex Operable Unit
Guam, USA

1.2 STATEMENT OF BASIS AND PURPOSE

This decision document, a Record of Decision (ROD), presents the selected remedial actions for soil and groundwater at the Marianis/Bonins Command (MARBO) Annex Operable Unit (OU) at Andersen Air Force Base (AFB), Guam. The selected remedial alternatives were chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The MARBO Annex OU includes six sites within the property line of the MARBO Annex, and groundwater underlying the Annex. This decision is based on the Administrative Record for this site and complies with 40 Code of Federal Regulations (CFR), Part 300. The purpose of this ROD is to set forth the remedial action to remediate soil and groundwater that has been impacted by past activities at Andersen AFB.

The U.S. Air Force (USAF), U.S. Environmental Protection Agency (USEPA) Region IX, and the Guam Environmental Protection Agency (GEPA) concur with the selected remedy.

1.3 ASSESSMENT OF THE SITE

Risks to human health and the environment were evaluated for groundwater underlying MARBO and at six surface sites within MARBO. No risk was found at Waste Pile 5 and the War Dog Borrow Pit, so no further action is planned for these two sites. Current risks associated with soil

exceed acceptable risk levels at Waste Pile 6, Waste Pile 7, Landfill 29, and the MARBO Laundry, thus remedial alternatives were evaluated for these four sites (ICF, 1996). Current risks associated with contaminants in groundwater at the MARBO Annex are within the acceptable risk management range utilized by the USEPA. Trichloroethylene (TCE) and tetrachloroethylene (PCE) concentrations in groundwater still exceed the Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) in two locations, thus requiring an analysis of remedial alternatives.

Actual or threatened releases of hazardous substances from the four soil sites, if not addressed by implementing the remedial actions presented in this ROD, may present a risk to public health, welfare, or the environment.

1.4 DESCRIPTION OF THE SELECTED REMEDY

This ROD addresses the selected remedy for soil at the four sites, as well as groundwater underlying the MARBO Annex OU. The MARBO Annex OU is the first of four OU's at Andersen AFB to complete the CERCLA regulatory process, which includes site investigation and the recommendation of remedial alternatives for soil and groundwater, if necessary.

1.4.1 Soil

Based on alternatives evaluated in the OU 3 Focused FS (ICF, 1997a) the US Air Force, the USEPA, and Guam have selected Soil Removal (Alternative OU3-D) as the remedy for three of the sites, and Soil Cover (Alternative OU3-C) for one of the sites. The alternatives are described briefly below:

Soil Removal is the selected alternative for Sites 22 (Waste Pile 6), 24 (Landfill 29) and 38 (MARBO Laundry). The Constituents of Concern (COCs) at the four sites include polychlorinated biphenyl (PCB) Aroclor 1254; metals lead, antimony, cadmium, chromium and arsenic; and polycyclic aromatic hydrocarbons (PAH's) benzo(a)anthrocene, benzo(a)pyrene,

benzo(b)fluoranthene and indeno (1,2,3 cd) pyrene. The soil removal alternative consists of the following:

- Site preparation for soil removal and preparation of appropriate construction support plans (e.g., Health and Safety Plan, Quality Assurance Project Plan, and Environmental Response Plan);

- Excavation of soil with contaminant concentrations exceeding cleanup screening criteria. Backfill and compaction of the excavations with clean soil will be performed. Confirmatory sampling will be performed after an excavation to verify that soil exceeding the screening criteria is removed;

- Soil and debris disposal. Impacted soil and debris which are considered non-hazardous will be excavated and disposed of as solid waste in the Andersen AFB solid waste landfill. If the soil and debris are considered hazardous (based on a Toxicity Characteristic Leachate Procedure [TCLP] - analysis), then it will be consolidated for off-island disposal at a licensed hazardous waste facility;

- Public meetings to inform Andersen AFB personnel and local residents of potential risks during and after soil removal. Risks may include the exposure risk during soil removal and/or residual risk after soil removal (residual risk is expected to be within USEPA's risk management range). This effort will be completed as part of the existing community relations program established at Andersen AFB.

Soil Cover is the selected alternative for Site 20 (Waste Pile 7). The COC's for Site 20 include pesticides 4,4'-DDE, 4,4'-DDT, Dieldrin, alpha-chlordane and gamma-chlordane; PCB Aroclor 1260; and the metal lead. The soil cover alternative consists of the following:

- Site preparation for soil-fill stockpile areas, and preparation of appropriate construction support plans (e.g., a Health and Safety Plan, Quality Assurance Project Plan, and Environmental Response Plan);

- Soil cover construction over 1.8 acres of Site 20. Fill consisting of locally available crushed coral will be used to establish a subgrade layer up to 6 inches in depth that will be followed with a 12-inch soil layer consisting of clayey silt obtained from borrow sources on the island. In addition, a final 6-inch soil layer, obtained locally, will be used to accommodate the root system of the vegetation established over the covered area;

- A fence will be constructed around the site to prevent access during revegetation. Signs will be posted to restrict access to the site, and deed restrictions to place legal constraints on any future use of the site;

- Public education to inform Andersen AFB personnel and local residents of potential risks during soil cover construction and after completion of the soil cover. Risk education will address exposure risk during soil cover construction and residual risk after installation of the soil cover (residual risk is expected to be within USEPA's risk management range). This will also include public meetings and presentations, press releases, and posting of signs where appropriate. Similar to the Soil Removal Alternative, this effort will be completed as part of the existing community relations program established at Andersen AFB.

- A review of site conditions every 5 years. Periodic reviews will include an evaluation of existing and new information along with an assessment of the future use of the site.

1.4.2 Groundwater

Based on alternatives evaluated in the OU 2 Focused FS (EA and Montgomery Watson, 1997) the USAF, the USEPA, and the Guam EPA have selected Natural Attenuation with Wellhead Treatment (Alternative G-2) as the remedy for the TCE and PCE contaminated groundwater beneath the MARBO Annex. The remedy addresses the principal threat of elevated concentrations of TCE and/or PCE in the drinking water through monitoring existing wellhead treatment and institutional controls. The potential threat of further migration of TCE and/or PCE is addressed via long-term monitoring. The selected remedy consists of:

- Natural attenuation of TCE and PCE in the aquifer. TCE and PCE concentrations in groundwater indicate an overall decreasing trend, and are expected to decrease to concentrations below federal MCLs;

- Continued wellhead treatment at those wells which are presently undergoing Air Stripping. The treatment of these wells will continue until influent TCE and PCE concentrations are consistently below federal MCLs;

- Long-term sampling and monitoring of select production and monitoring wells in the MARBO Annex, and adjacent to the MARBO Annex. The frequency and number of wells to be monitored will be addressed every two years, in conjunction with the Basewide Groundwater Monitoring Plan.

- Institutional controls to monitor groundwater development in those areas impacted by TCE and PCE. This will be done primarily through Guam's Groundwater Protection Zone Policies.

1.5 STATUTORY DETERMINATIONS

The selected remedies are protective of human health and the environment, comply with Federal and Territory requirements that are legally applicable or relevant and appropriate to the remedial action, and are cost-effective. These remedies utilize permanent solutions to the maximum extent practicable. The benefit resulting from treatment of the soil and groundwater would result in substantial and disproportionate effort and cost, thus the soil and groundwater remedies do not satisfy the statutory preference for treatment as a principal element of the remedy. The depth to groundwater in a highly conducive aquifer precludes a remedy where groundwater could be treated effectively. The small volume of soil and distribution of contaminants at Waste Pile 7 similarly precludes a treatment alternative. Because the remedy for Waste Pile 7 will result in hazardous substances remaining on-site above health based levels, a review will be conducted within five years after the commencement of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment. A review of the selected groundwater alternative will occur every five years as part of the ROD process, and every two years to evaluate the frequency and number of wells which require long-term monitoring as part of the Andersen AFB Long-Term Monitoring Plan.

1.6 SIGNATURES

The following pages are signature pages for the Air Force, United States Environmental Protection Agency, Region 9 and the Guam Environmental Protection Agency.

Eugene D. Santarelli

Eugene D. Santarelli
Lieutenant General, USAF
Vice Commander, Pacific Air Forces (PACAF)

3 AUG 1998
Date

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Dan Opalski
Chief Federal Facilities Cleanup Branch
U.S. Environmental Protection Agency Region IX

6/16/98
Date

TERRITORY OF GUAM ENVIRONMENTAL PROTECTION AGENCY

7-17-98

Jesus Salas
Administrator
Guam Environmental Protection Agency

Date

2.0 DECISION SUMMARY FOR SOIL

This decision summary provides a description of the MARBO Annex and the six Installation Restoration Program (IRP) sites, including the regional setting, physiography, meteorology, demography and land use, hydrology, hydrogeology, and water use. This section also summarizes legal and public involvement issues, site risks, remedial alternatives, the rationale for the selection, and how the selected remedy satisfies statutory requirements. The site investigation and risk assessment is included in the OU 3 Remedial Investigation (RI) report, conducted and written by ICF Technology, Incorporated (ICF, 1996). The evaluation of remedial alternatives was also performed by ICF, and is included in the OU 3 Focused Feasibility Study (FFS) report (ICF, 1997a).

2.1 SITE NAME, LOCATION, AND DESCRIPTION

Andersen AFB is located on the northern half of the island of Guam. The largest island in the Mariana Islands, Guam is located in the western Pacific region, approximately halfway between Japan and New Guinea, between latitudes 13° 15° N. and 13° 39° N. and longitudes 144° 37° E. and 144° 57° E. The island covers an area of nearly 209 square miles, and is approximately 30 miles long and from 4 to 8 miles wide (Figure 2-1). Andersen AFB is located on the northern half of the island which is a broad undulating limestone plateau overlying a volcanic core.

Andersen AFB consists of several parcels of land located in the northern portion of the island, comprising North and Northwest Fields, and is 8 miles wide, between 2 and 4 miles long, and covers approximately 24.5 square miles. It is bounded on the east, north and west by cliffs rising about 500 feet above the ocean. The active base operations are located on the Main Base. Northwest Field has been generally inactive since the mid 1950s. Several non-contiguous properties are also part of Andersen AFB. The Harmon Annex contains a 2.8-square-mile area along the west side of the island, 4 miles south of Northwest Field, and is sparsely populated. The MARBO Annex, which contains the six sites addressed in this section, lies 4 miles south of North and Northwest Fields, and covers a 3.8-square-mile area (Figure 2-2).

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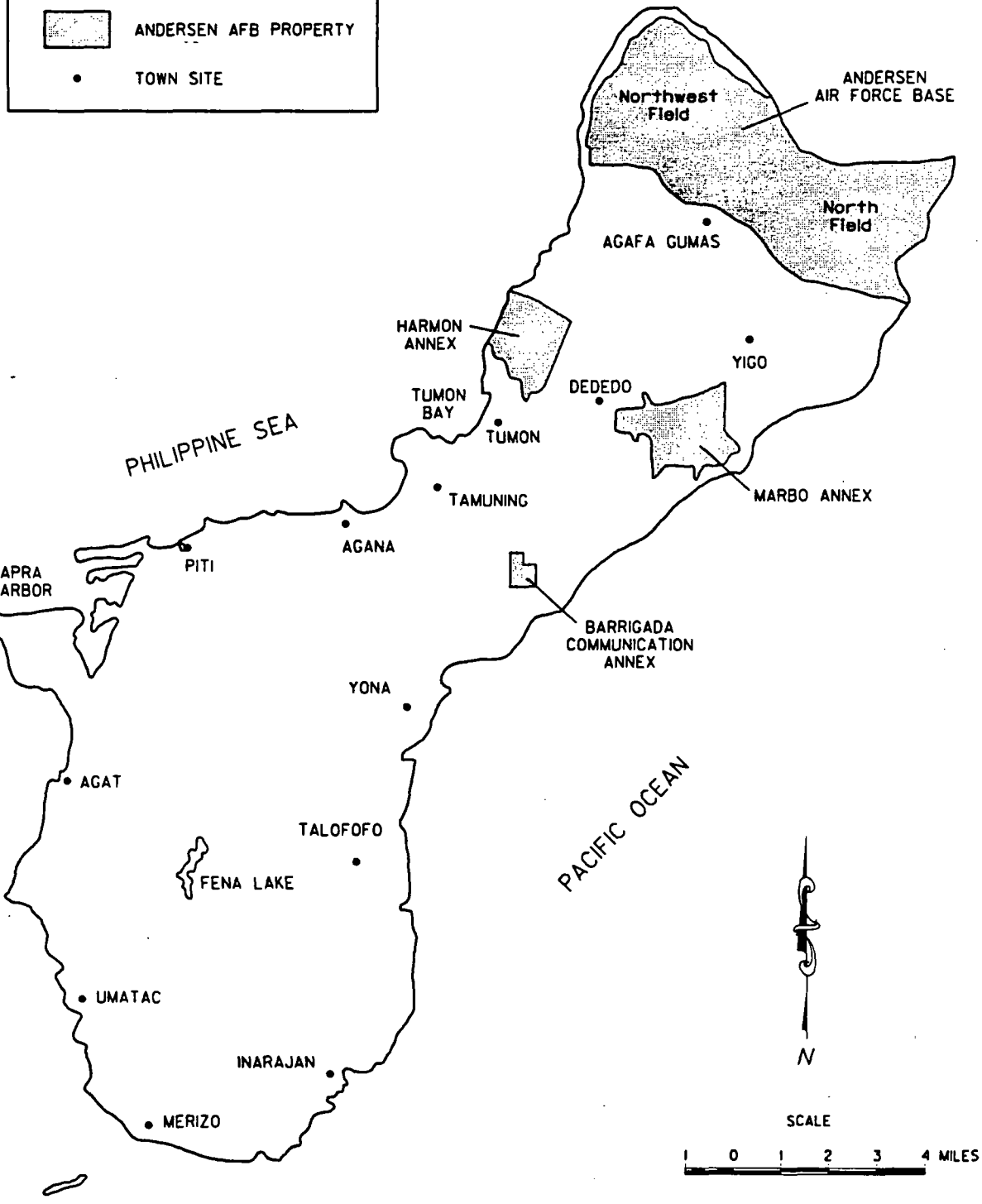
REVISED: 04/15/98



SOURCE: ESE, 1985

FIGURE 2-1

MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM

BASE LAYOUT

DATE: 9/29/97

SCALE: AS NOTED

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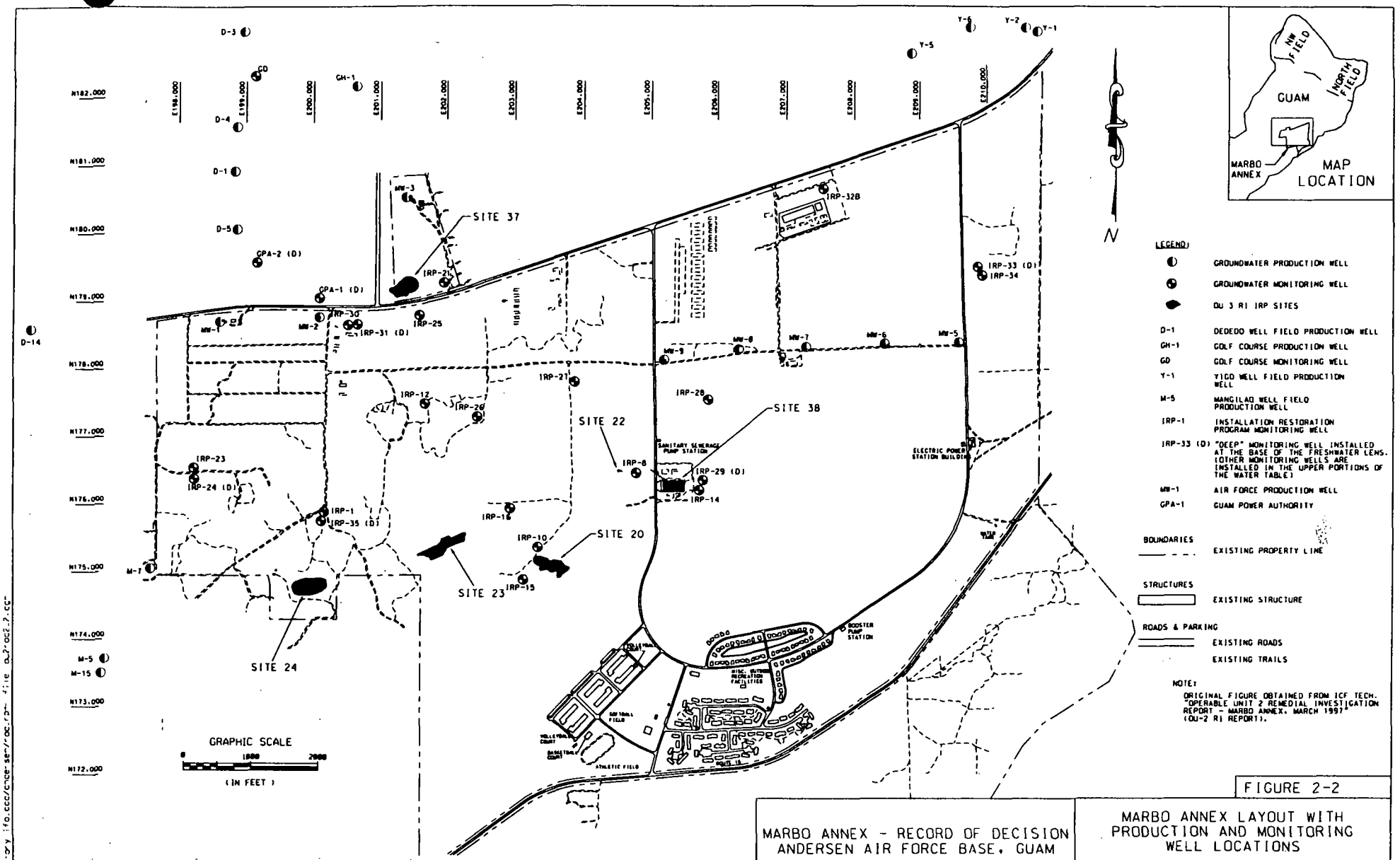

FIGURE 2-2

MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM

MARBO ANNEX LAYOUT WITH PRODUCTION AND MONITORING WELL LOCATIONS

DATE: 9/29/97 | SCALE: AS NOTED

2.1.1 Site 20 (Waste Pile 7)

Waste Pile 7 is located in the south-central portion of the MARBO Annex (Figure 2-2). Waste Pile 7 is an abandoned quarry that is partially filled with waste, and covered with soil and vegetation. The "Buried Waste Area," which was the focus of the investigation, covers approximately 1.84 acres in size and has an average depth to the bottom of the fill layer of 10.8 feet.

Based on information from previous IRP studies and site visits conducted in 1992, Waste Pile 7 was thought to consist of two separate disposal areas (Figure 2-3). Area A was considered to be a former quarry that was partially filled with waste, and covered with soil and vegetation. Area B adjoins the Area A quarry, and based on site inspections performed in the summer of 1992, was suspected to contain numerous mounds of soil-covered construction debris. Following a review of historical records, a topographic survey, a detailed site inventory, exploratory excavations, and geophysical and soil gas surveys, Area A was found to be a former quarry partially filled with waste and soil, and covered with vegetation (ICF, 1996). The mounds in Area B were found to consist of mostly soil with very limited scattered debris. These mounds may have been created by the removal of soil from the Area A quarry at the initiation of quarry operations.

As a result of these findings, the boundary of Waste Pile 7 was redefined to include only the portion of the Area A quarry that contained buried waste. Additional sampling was also conducted at a soil mound in Area B and at an Empty Drum Area southwest of the Buried Waste Area. For reference, the original site reconnaissance boundary, and other boundaries discussed here are shown on Figure 2-3. Based on a risk evaluation of soil analytical data, a health risk was identified for this site. The COCs identified at Site 20 include pesticides 4,4'-DDE, 4,4-DDT, Dieldrin, alpha chlordane and gamma chlordane; the PCB Aroclor 1260; and the metal lead.

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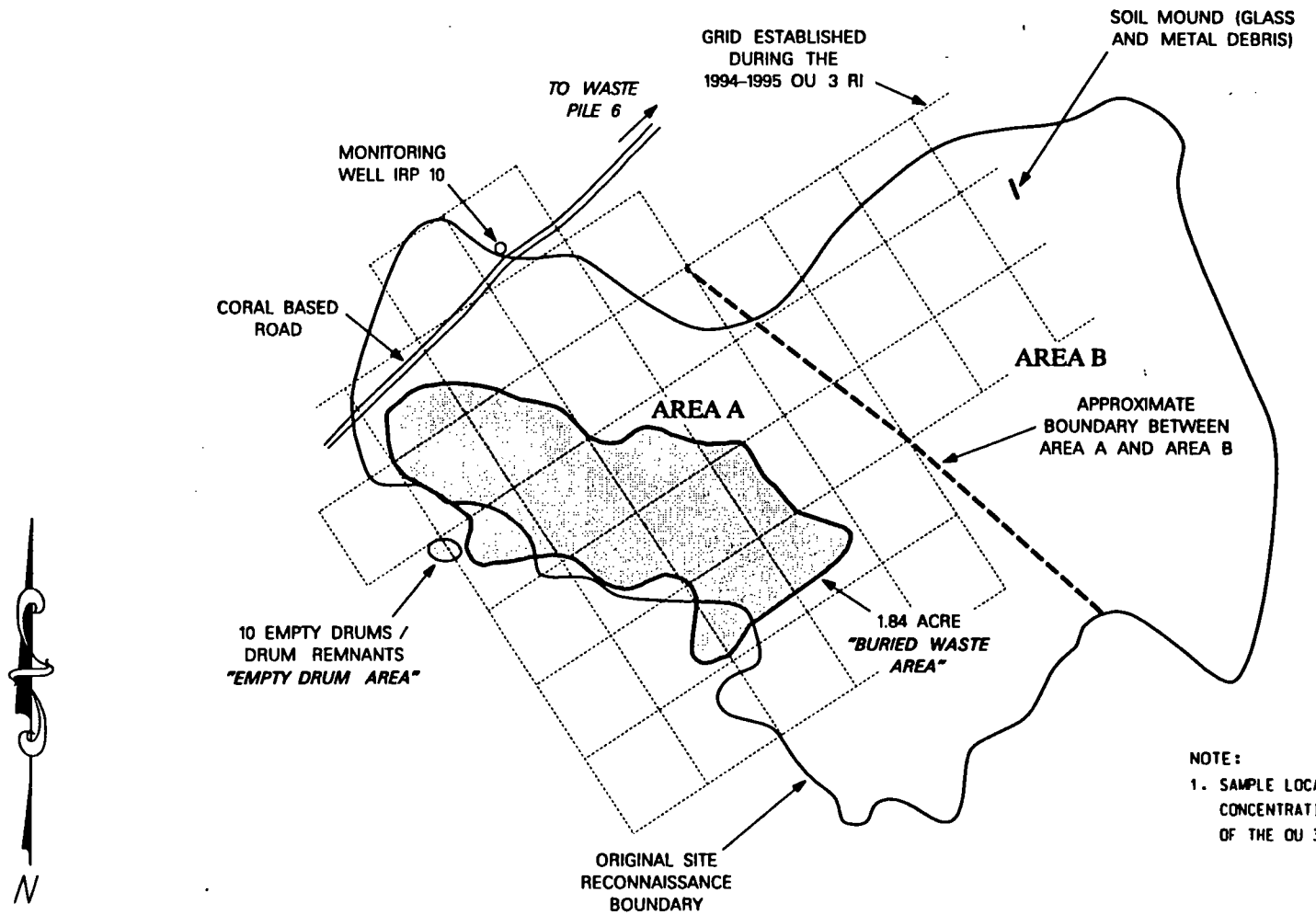

NOTE:
1. SAMPLE LOCATIONS AND CONSTITUENT CONCENTRATIONS ARE IN SECTION 3 OF THE OU 3 RI REPORT (ICF, 1996)

GRAPHIC SCALE
0 100 200
(IN FEET)

FIGURE 2-3

MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM

DISPOSAL/SPILL AREA LOCATIONS
SITE 20 (WASTE PILE 7)
MARBO ANNEX

DATE: 9/29/97

SCALE: AS NOTED

2.1.2 Site 22 (Waste Pile 6)

Waste Pile 6 is a small site located centrally within the MARBO Annex as shown in Figure 2-2. Based on information from previous IRP studies and site visits, the boundary of Waste Pile 6 was thought to encompass a large areal expanse (Figure 2-4). As with Waste Pile 7, however, the original boundaries of Waste Pile 6 were re-established after completion of a more thorough review of historical records, a topographic survey, a detailed site inventory, geophysical surveys, exploratory excavations, and soil gas sampling (ICF, 1996).

This characterization identified several discrete disposal/spill areas throughout the area and vicinity of Waste Pile 6, shown and described on Figure 2-4. The depth of contamination in these areas ranges from surface debris to approximately 8.5 feet bgs. Soil analytical data indicated seven disposal/spill areas which represent a health risk, including: 1) an area containing six car battery casings ("Car Battery Area"); 2) an area containing nine apparent alkaline radio batteries ("Radio Battery Area"); 3) an area containing three "possible" batteries ("Unknown Battery Area"); 4) a pile of roofing material ("Roofing Material Pile"); 5) an area containing subsurface metal debris ("Metal Debris Pile"); and 6) an area where empty drums were detected in the shallow subsurface ("Empty Drum Pile"). The seventh area is a drum pile containing about 108 deteriorated drums of paving grade asphalt, conservatively estimated to be approximately 2,900 gallons in volume ("Asphalt Drum Pile"). Most of the drums were stacked together in rows, and several had leaked onto the ground. Based on a risk evaluation of soil analytical data, a health risk was identified for this site. The COCs identified at Site 6 include the metals antimony, arsenic, cadmium and lead; and PAHs benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene and indeno (1,2,3 cd)pyrene.

2.1.3 Site 23 (Waste Pile 5)

Waste Pile 5 is located in the south-southwest section of the MARBO Annex, approximately 1,500 feet west of Waste Pile 6 (Figure 2-2). The site investigation focused on a 2.17-acre trench landfill that consisted of eight large trench-like waste disposal cells containing mostly municipal

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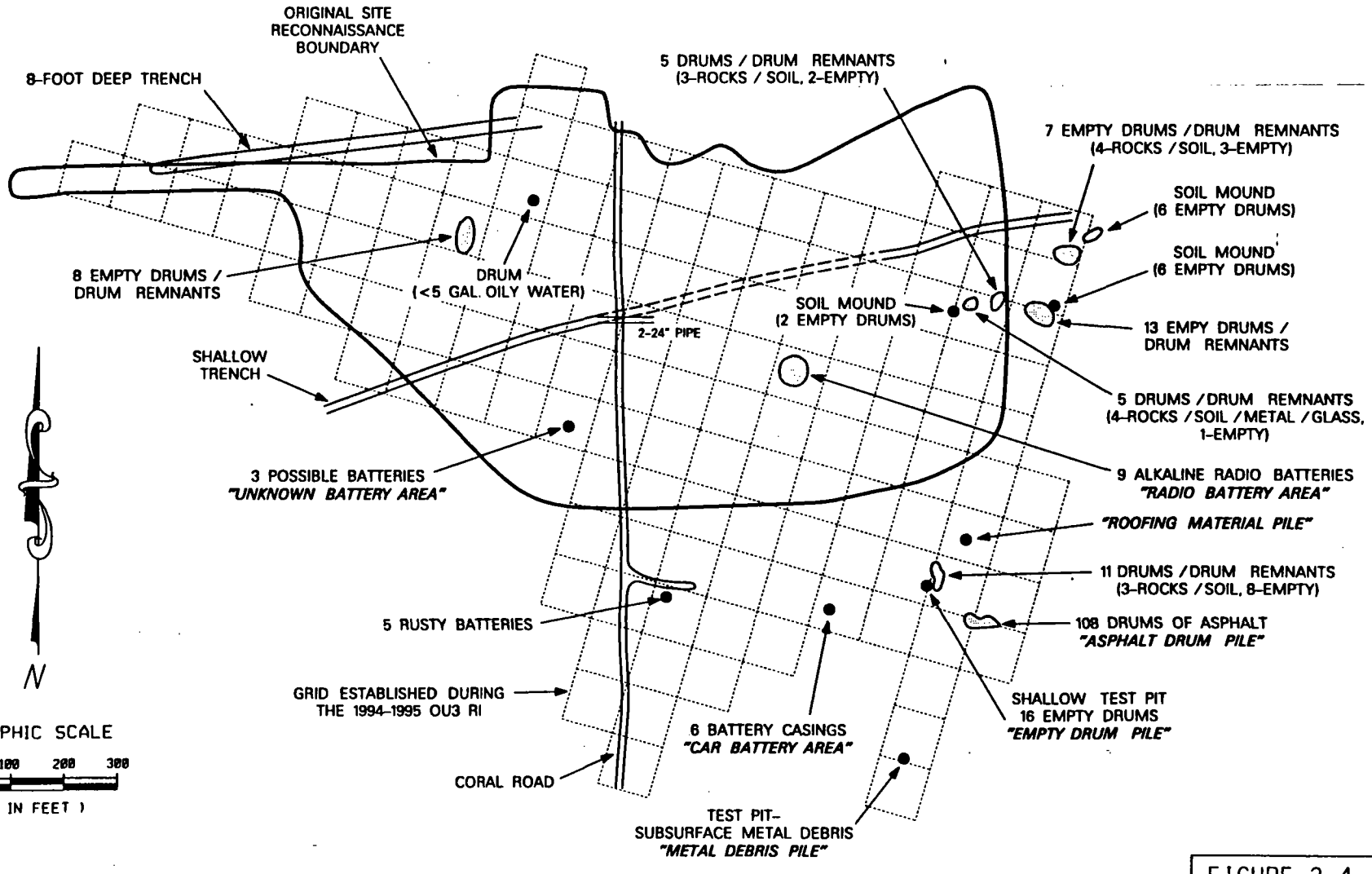

NOTE:
1. SAMPLE LOCATIONS AND CONSTITUENT CONCENTRATIONS ARE IN SECTION 3 OF THE OU 3 RI REPORT (ICF, 1996)

FIGURE 2-4

MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM

DISPOSAL/SPILL AREA LOCATIONS
SITE 22 (WASTEPILE 6)
MARBO ANNEX

DATE: 9/29/97

SCALE: AS NOTED

trash such as bottles, cans, cardboard paper, kitchenware; and construction debris, including concrete, pipe fragments, and corrugated metal. A total of 25 drum/drum fragments were observed on the surface in 16 locations. Sixteen of the drums were empty and the rest contained soil, rocks and concrete. The lengths of the trenches ranged from 150 feet to 650 feet. Measurements taken during excavations showed the average thickness of the fill layer was 7.5 feet (range 1.5 to 14.5 feet), and the average depth to the bottom of the fill layer was 10.8 feet (range 6 to 17 feet) below ground surface (bgs). The surface of this landfill did not contain a uniform cap or cover, but was vegetated and covered with soil and debris. Some trenches contained several feet of debris-free soil above the fill material, whereas other trenches contained debris throughout. No health risk was identified at Waste Pile 5.

2.1.4 Site 24 (Landfill 29)

Site 24 is located in the southwest portion of the MARBO Annex, as shown on Figure 2-2. As with Waste Piles 6 and 7, a more thorough field investigation indicated that the original Site 24 boundary did not outline a true disposal site (i.e., a landfill or consolidated waste dump), but instead was an abandoned quarry containing scattered debris such as drum remnants and metal (Figure 2-5). The focus of the investigation was on three primary areas, including: 1) a 2.44-acre landfill located south-southwest of the original location, 2) an area west of the original location containing soil-filled drums ("Surface Drum Area"), and 3) a small area which identified shallow subsurface metal debris ("Subsurface Metal Area").

The 2.44-acre area landfill contained mostly municipal waste (i.e., bottles, cans, etc.), as well as other types of wastes such as ferrous and copper metal debris, and crushed empty deteriorated drums. Measurements taken during excavations showed the average thickness of the fill layer was 4.2 feet (range 3 to 6.5 feet), and the average depth to the bottom of the fill layer was 6.2 feet (range 5 to 8.5 feet) bgs. The waste material was covered with a relatively uniform 2-foot layer of recemented limestone and several inches of soil. The surface of the landfill was vegetated. The Surface Drum Area contains an estimated 86 empty or soil-filled drums/drum remnants, and the Subsurface Metal Area contains subsurface metal debris. Both of these areas are shown on

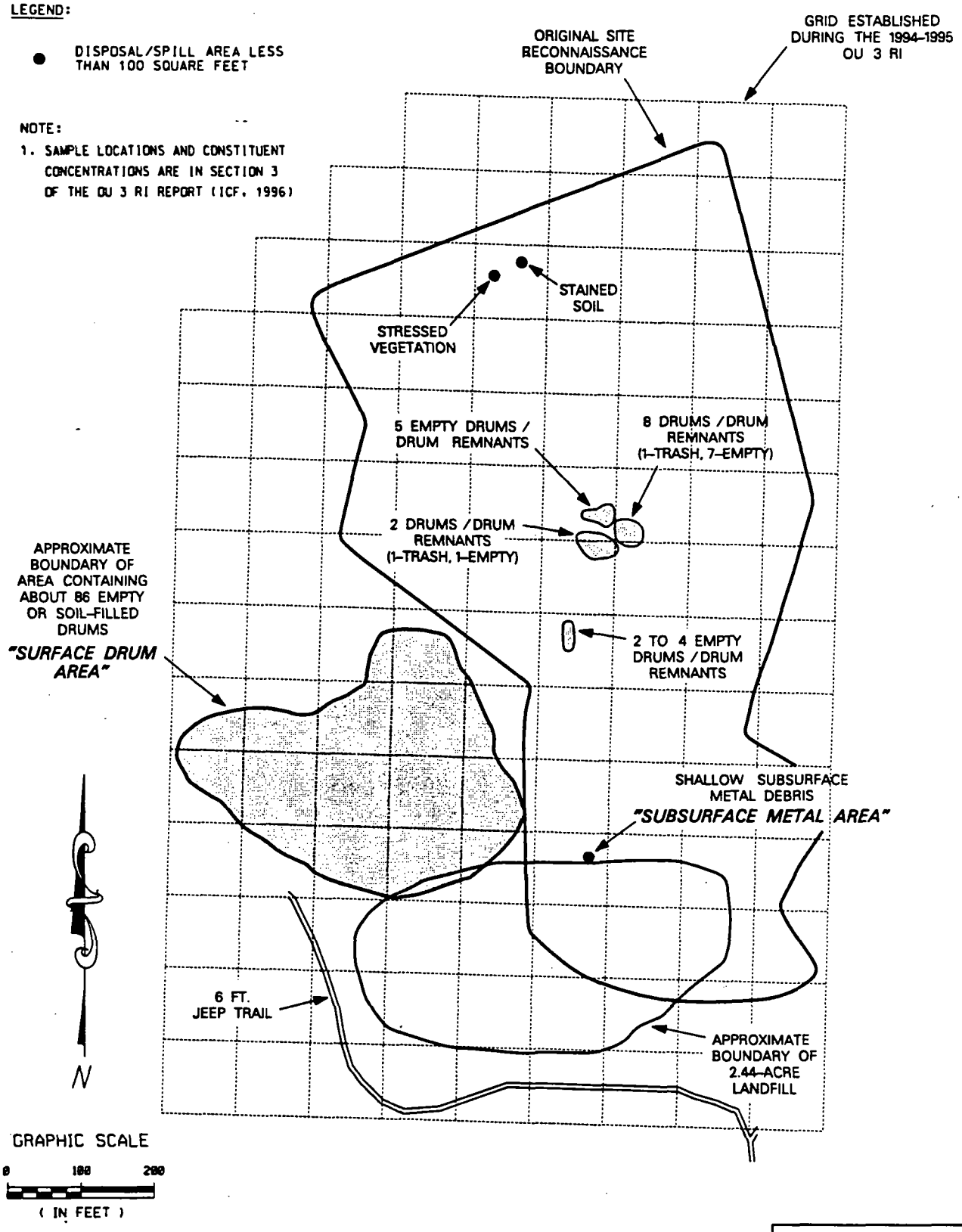

FIGURE 2-5

MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM

DISPOSAL/SPILL AREA LOCATIONS
SITE 24 (LANDFILL 29)
MARBO ANNEX

DATE: 9/29/97

SCALE: AS NOTED

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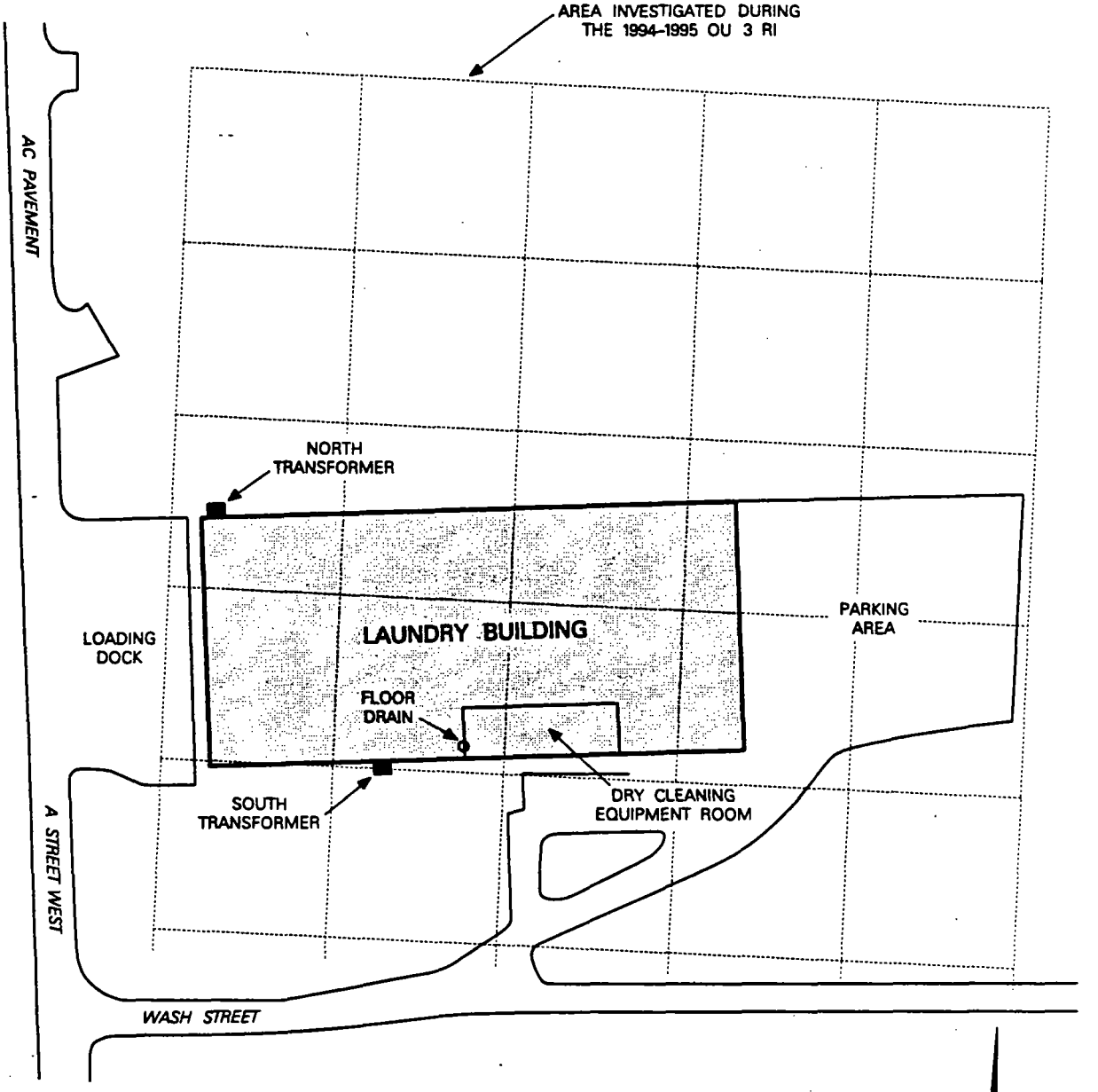
Figure 2-5. The COCs identified at Site 24 include the metals antimony and lead. Based on a risk evaluation of soil analytical data, a health risk was identified for this site.

2.1.5 Site 37 (War Dog Borrow Pit)

The War Dog Borrow Pit is an abandoned quarry in the northernmost portion of the MARBO Annex, located adjacent to Route No. 1, near the former location of the War Dog Cemetery (Figure 2-2). The site investigation focused on a 1.82-acre area landfill within the quarry that contained scrap automobile parts. Measurements taken during excavations showed the average thickness of the fill layer was 4.8 feet (range 2.5 to 8.5 feet), and the average depth to the bottom of the fill layer was 6.8 feet (range 4.5 to 8.5 feet) bgs. The fill layer was covered with about 2 feet of recemented limestone. The limestone cover was exposed in some areas, whereas other areas contained surface soil and vegetation. Miscellaneous trash was widely distributed on the ground surface, and several soil mounds of various sizes were located across the site. No health risk was identified at the War Dog Borrow Pit.

2.1.6 Site 38 (MARBO Laundry)

The MARBO Laundry is located in the eastern half of the MARBO Annex, as shown on Figure 2-2. The MARBO Laundry was a military laundry facility operated in Building 01125 between 1948 and 1973 (Figure 2-6). The laundry was modified in 1970 with the addition of a dry cleaning facility. This facility may have discharged solvents to the base sanitary sewer via a floor drain in the dry cleaning room. Building 01125 has since been utilized as a storage facility for furniture, among other uses. The building was renovated immediately before and during the OU 3 sampling. The renovation included scraping old paint from the outside walls which caused paint chips to be deposited on the ground surface (grass or soil) outside the building where surface soil samples were collected. The COCs identified at the MARBO Laundry include the PCB Aroclor 1254, and the metal lead. Based on a risk evaluation of soil analytical data, a health risk was identified for soil surrounding the facility as well as for the north and south transformers, as shown on Figure 2-6.



NOTE:

1. SAMPLE LOCATIONS AND CONSTITUENT CONCENTRATIONS ARE IN SECTION 3 OF THE OU 3 RI REPORT (ICF, 1996)

GRAPHIC SCALE

0 50 100

(IN FEET)

N

FIGURE 2-6

MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM

DISPOSAL/SPILL AREA LOCATIONS
SITE 38 (MARBO LAUNDRY)
MARBO ANNEX

DATE: 9/29/97

SCALE: AS NOTED

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2.2 REGIONAL PHYSIOGRAPHY

Andersen AFB is located in the Northern Physiographic Province of Guam, which is characterized by a broad undulating limestone reef plateau. Numerous sinkholes are present on the northern plateau. The sinkholes and the very porous limestone bedrock provide rapid surface water infiltration with ultimate percolation to the underlying fresh water aquifer. The surface of the limestone plateau is interrupted by two volcanic peaks, Mount Santa Rosa and Mataguac Hill located northeast and north of the MARBO Annex, at elevations of 828 and 630 feet above mean sea level (msl), respectively (Figure 2-7). Surface elevations of the limestone plateau range from 300 to over 500 feet msl in the MARBO Annex area. The northern limestone plateau (where AAFB is located) is bounded by the Pacific Ocean to the east side and the Philippine Sea to the west. Several beach terraces formed by eustatic sea level fluctuation, exist between the edge of the sea and the foot of the cliff forming narrow coastal lowland areas.

2.2.1 Geology

The geology underlying the MARBO Annex consists of limestone reef deposits underlain by volcanic rocks. The volcanically derived Alutom formation consists of thick sequences of water-laid tuffaceous shales containing pyroclastic deposits of ash, dust, sandstones, and conglomerates. Interlayered within this formation are lava flows, breccia, and fragments of reef limestones. The Alutom formation is the oldest rock unit on Guam with deposition occurring during the Eocene (57 to 36 million years before present) and Miocene (24 to 5 million years before present) epochs. This formation outcrops in northern Guam at Mount Santa Rosa and Mataguac Hill, and underlies the limestone plateaus beneath the MARBO Annex.

The MARBO Annex is underlain by the Barrigada and Mariana limestone formations (2 to 5 million years before present) which is underlain by the Alutom formation. The Barrigada formation is generally a deep water deposit of fine grained texture, composed of foramanifera tests. The Barrigada limestone was deposited on the volcanically derived Alutom formation and

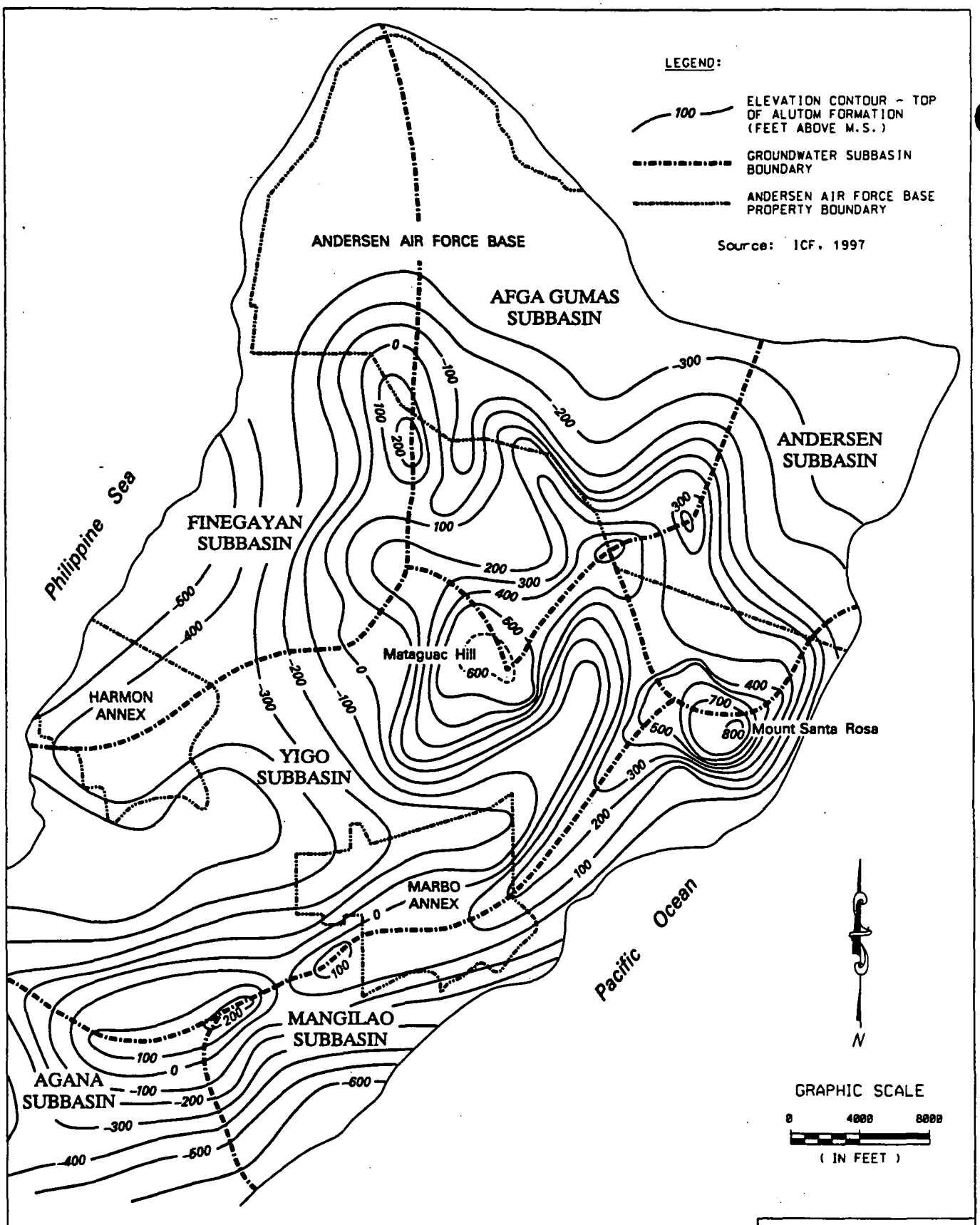

FIGURE 2-7

MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM

STRUCTURE CONTOUR AND SUBBASIN MAP - NORTHERN GUAM (TOP OF THE ALUTOM FORMATION)

DATE: 10/6/97

SCALE: AS NOTED

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forms an outcropped semi-circle around the edges of the MARBO Annex. Maximum thickness of this formation exceeds 540 feet (Tracey et al., 1964). The younger Mariana limestone includes approximately 80 percent of the exposed reef-associated limestones of Guam. This formation onlaps the Barrigada limestone as a vertical and transgressional facies change from a deep to a shallow water depositional environment.

2.2.2 Hydrogeology of Northern Guam

Throughout most of northern Guam, fresh groundwater floats on seawater in an approximate buoyant equilibrium, described by the Ghyben-Herzberg model, which, when combined with the effect of dynamics of flow of the freshwater, results in a lens-shaped body of freshwater (Ward et al., 1965). Groundwater resources are primarily found in the northern half of the island in porous limestone deposits of the Barrigada and Mariana formations. The groundwater is encountered approximately 300-500 feet bgs. The groundwater surface generally coincides with sea level and the depth to water depends on surface elevation. The thickness of the lens is generally around 90 to 120 feet. Freshwater is drawn from this aquifer, which is known as the Northern Guam Lens (NGL). The NGL and its subsurface groundwater subbasin divides are discussed below and are shown on Figure 2-7.

The NGL is a dynamic system; water is in constant motion from areas of recharge to areas of discharge. The energy involved in this movement affects the shape of the lens and the depth of the freshwater. The important factors governing the amount of freshwater in the lens are: the effects of mixing freshwater and marine water, the permeability of the limestone formations, and the rate of recharge (discussed below) (Ward et al., 1965). Regionally, the groundwater flow direction in the NGL is from the limestone/volcanic contacts toward the sea. Flow can be affected by faults, fractures, brecciated zones, joints, vertical and horizontal solution channels or cavities, lithology, and by pumping wells.

Mink (1976), identified the NGL as consisting of two parts: the basal and parabasal groundwater. The basal lens is that portion of the freshwater described by the Ghyben-Herzberg model. The

lower boundary of the freshwater lens in the basal portion consists of the transition zone and seawater. Moving inland away from the coast, the base of the lens is intercepted by the rising surface of the volcanic Alutom formation. It is at this point that the Ghyben-Herzberg model ceases to be the controlling factor in the definition of the base of the freshwater lens. The volcanic surface becomes the lower boundary condition and water resting on the relatively impermeable volcanic unit is referred to as parabasal groundwater.

The NGL study (NGLS-CDM, 1982) divided the aquifer under the Northern Plateau (i.e., the NGL) into six hydrogeologic subbasins (Figure 2-7). Subbasin boundaries were drawn along sub-topographic divides on the top of the Alutom Formation depicted from geophysical methods. Five of the subbasins (Andersen, Agafa Gumas, Finegayan, Mangilao, and Yigo) underlie Andersen AFB properties. The MARBO Annex lies within the Yigo and Mangilao subbasins, however the Mangilao subbasin was not included as part of the MARBO Annex remedial investigation (RI) because there are no remedial investigation/feasibility study (RI/FS) sites in the subbasin.

The following subsections briefly discuss a compilation of studies performed by the United States Geological Survey (USGS), the Water and Energy Research Institute and the Groundwater Resources of Guam on the hydraulic properties and subdivisions of the aquifer.

Porosity. Spatial variation in porosity of the Barrigada and Mariana limestone formations varies considerably depending on the depositional settings in the vicinity of the Northern Plateau. Openings can range in size from microscopic to large, well-developed cavern systems, but are generally about 1/8 to 1/4 inches in diameter and are the result of dissolution of the limestone.

Hydraulic Conductivity. Estimates of hydraulic conductivity within the NGL range over three orders of magnitude. Local hydraulic conductivity varies considerably because of the limestone matrix. Transmissivity, which is the product of hydraulic conductivity and thickness (and represents an aquifer's ability to transmit water), exhibits a 17-fold difference between lowest and highest values (Mink, 1976). The results of the NGLS (CDM, 1982) gave estimates of hydraulic

conductivities ranging from 2 to 20,670 feet per day (ft/day); these estimates were derived from various indirect methods, including head-gradient relationships, tidal attenuation, recovery tests, intrusion analyses, and numerical modeling techniques. The hydraulic conductivities and, as previously noted, the porosity of the limestone vary considerably both regionally and locally depending on the depositional setting.

Recharge. The MARBO Annex is underlain by highly permeable limestone. No perennial streams exist on the northern half of the island. During heavy rainfall, the surface water runoff may flow in short channels in the limestone, but it eventually disappears into the numerous dolines, fissures and other secondary porosity openings. The only runoff of consequence in the area occurs on the steep volcanic slopes of Mataguac Hill and Mt. Santa Rosa; however, the water eventually disappears into the limestone bedrock surrounding the hills (Ward and Brockhart, 1962). Once surface water seeps into the limestone bedrock surrounding the hills, it flows along the surface of the volcanic rock or as discrete recharge through caverns until it reaches the water table and becomes part of the parabasal lens.

Data obtained from the National Climatic Data Center covering the period 1957 to 1991 show that Guam rainfall averages almost 102 inches per year and is divided between two distinct seasons, rainy and dry. The rainy season begins in July and extends through November. Roughly 65 percent of the annual precipitation falls during these five months. The dry season extends from January through May and during this period water shortages are not uncommon. Both June and December are considered transitional months. The total annual recharge is essentially the amount determined by the annual precipitation minus evapotranspiration.

No data are available on the amount of rainfall returned to the atmosphere by vegetation transpiration. As a first approximation, studies to date have used a value for evapotranspiration equal to the pan evaporation rate reported by the National Weather Service (NWS) Station of the U.S. Weather Bureau at Finegayan, located just north of the Andersen AFB Harmon Annex, for the period 1974 through 1981. The reported average pan evaporation rate is about 7 inches per month during the dry season and about 6 inches per month during the wet season. The average

monthly pan evaporation is 6.85 inches and the annual average is about 82 inches. This compares favorably with calculated evapotranspiration rates, which range from approximately 40 to 80 inches per year (CDM, 1982).

Average recharge rates range from approximately 25 to 35 inches per year depending on the method used (CDM, 1982; Mink, 1976). Mink computed the recharge to Andersen AFB at 27.69 inches. Recharge to the NGL was estimated to be approximately 165 million gallons per day (mgd) (CDM, 1982).

Storativity. Storativity for an unconfined aquifer is essentially equal to the specific yield and is defined as the volume of water that an aquifer releases from storage per unit surface area of an aquifer per unit decline in hydraulic head. In the NGL, storativity is approximately equal to the porosity (i.e., between 0.1 and 0.2, dimensionless) (CDM, 1982).

Sustainable Yield. The estimated sustainable yield of the aquifer is reported to be 59 mgd, and an estimated 37 mgd is considered available for future development. Sustainable yield is defined as the maximum amount of water that can be continuously withdrawn from an aquifer (i.e., the NGL) without impairing the integrity of the lens and the water quality due to saltwater intrusion. Sustainable yield is not equal to recharge, for if all water contributed by recharge were extracted, the lens would slowly dissipate because of continued leakage along the coastline. The amount of freshwater loss to the ocean is estimated at 143 mgd, averaged annually (CDM, 1982). Typical production well yields are approximately 200 gallons per minute (gpm).

Groundwater Geochemistry. Water quality of the NGL was evaluated during the NGLS (CDM, 1982) and discussed in the Guam Water Facilities Master Plan Update (Barrett Consulting Group, 1992). The chemical characteristics that have been evaluated include those regulated under both the Safe Drinking Water Act and the Clean Water Act.

The general groundwater chemistry of the NGL indicates that the main chemical constituents are calcium, chloride, silica, nitrate, and magnesium. Chloride is a critical constituent because it

provides a measure of seawater intrusion, while calcium and magnesium concentrations allow for the computation of total hardness. Silica provides an index of the lithology in which the water moves. Nitrate can be useful as an indicator of surface infiltration.

The water quality indicator parameters suggest the groundwater is hard, based on an average hardness of 270 milligrams per liter (mg/L) measured as calcium carbonate ($CaCO_3$). Levels as high as 400 mg/L of $CaCO_3$ were measured during the evaluation, with the high hardness a result of the limestone bedrock. Other characteristics of the lens include nitrates ranging from 2 to 10 mg/L (as NO_3); specific conductance ranging from 300 to 1,300 micromhos; and chloride ranging from less than 30 mg/L in the parabasal lens to between 70 and 280 mg/L in the basal lens.

As noted in the OU-2 RI, pumping wells generally have an increased chloride concentration when compared to the monitoring wells, likely due to overpumping of the freshwater lens. Additional water quality parameters are discussed in Section 4.0 of the OU-2 RI.

2.2.3 Water Use

According to the Revised Guam Water Quality Standards adopted January 2, 1992, all groundwater in northern Guam, whether fresh or saline, is categorized as G-1 Resource Zone water. The primary use of groundwater within this zone is for human consumption. This category includes virtually all water in the saturated zone of Guam. Specifically, it includes all water occurring in the saturated zone below the groundwater table, all vadose water occurring in an unsaturated zone interval extending 100 feet above any water table, or to within 20 feet of the ground surface of all fresh groundwater bodies, all water of the basal and parabasal freshwater bodies, and all water of and below the freshwater/seawater transition zone beneath the basal water body. Because any water discharges within this zone will (by definition) be tributary to groundwater bodies which are actual or potential sources of fresh, potable water supply, no pollutant discharges to the groundwater within this zone are allowed.

Freshwater in the NGL is the principal source of potable water for Guam and represents almost the entire freshwater resource available for future development. The Yigo subbasin alone provides 100 percent of the drinking water for Andersen AFB as well as a significant portion of the civilian supply. Guam drinking water comes from groundwater production wells installed in the upper portion of the aquifer. According to the Guam Water Facilities Master Plan Update (Barrett, 1992), there are 117 production wells on Guam with a total average withdrawal rate of 28 mgd. The water from these wells is mixed and treated in distribution tanks prior to distribution throughout the northern part of Guam. Water from the wells in the MARBO Annex area is distributed, along with water produced in other locations, to Dededo, Yigo, Barrigada, Mangilao, and Andersen AFB, where the total civilian water usage was reported to be approximately 17 mgd. Andersen AFB reportedly produces 5.19 mgd, 0.38 mgd of which is supplied to the Public Utility Agency of Guam (PUAG) distribution system (Barrett, 1992). There are currently eight Air Force production wells located on the MARBO Annex (MW-series wells).

2.2.4 Andersen AFB Soils

The primary geographic area in which all the investigated OU 3 sites are located is the limestone uplands. The MARBO Annex area has one mapped soil type: the Guam series. The Guam series consists of a shallow, well-drained, moderate to highly permeable soil that is found on uplifted plateaus. This soil formed in sediment overlying porous coralline limestone, with slopes of 0 to 15%. This soil is characteristically a dark reddish brown, cobbly clay loam; moderate to very fine granular structure; friable; slightly sticky, and slightly plastic with about 10% pebbles and 10% cobbles in the upper 2 inches. From 2-8 inches, soil is a gravely clay loam, moderate to fine granular structure; very friable; slightly sticky, and slightly plastic; and increasing amounts of pebbles. Below 8 inches, porous limestone is generally encountered.

2.2.5 Climatology and Meteorology

This section presents data describing the climatic conditions, seasonal changes, temperatures, rainfall and evaporation rates, and ambient air quality for the island of Guam.

Precipitation. Guam has distinct dry and rainy seasons. The rainy season typically begins in July and extends through November. Roughly 65% of the annual precipitation falls during these 5 months. Tropical storms are frequent during the rainy season, and occasionally they increase in intensity to become typhoons. The dry season extends from January through May, and during this period, water shortages are not uncommon. Both June and December are considered transitional. The average annual rainfall ranges from approximately 72 inches to approximately 112 inches. As noted earlier, the average annual rainfall measured at Andersen AFB on the Northern Plateau is approximately 100 inches.

Temperature. Guam lies about 13° (900 miles) north of the equator, which creates a year-round warm climate. Temperatures accompanied by high humidity range from the low 70s to the middle 80s. The average annual temperature is 79.6°F. The mean monthly temperatures range from 80°F (26.7°C) during January to 82°F (27.8°C) in June. Rarely does the temperature exceed 90°F (32.2°C) during the daytime hours or fall below 70°F (21.1°C) at night. The humidity ranges from 65 to 80% in the late afternoon and 85 to 100% at night with a monthly average of at least 66%.

Wind. The dominant winds are the trade winds, blowing from the east or northeast with velocities between 4 and 12 miles per hour (mph) throughout the year. These winds are strongest during the dry season, averaging 15 to 25 mph and calms are rare. During the wet season, the trade winds are still dominant, but not constant. The winds can blow from any direction with windspeeds generally less than 15 miles per hour, interspersed with frequent calms. Storms may occur at any time during the year, but are most common during the wet season. Although typhoons can occur at anytime, their likelihood is greatest from July through September.

Evaporation and Evapotranspiration. The average pan evaporation is reported to be about 7 inches per month during the dry season and about 6 inches per month in the wet season. The average monthly pan evaporation is 6.85 inches and the annual average is about 82 inches.

Evapotranspiration is the combined total of evaporation and plant transpiration which occurs if the vegetation has a continuous supply of water. To estimate recharge of the fresh water lens, the rate of evapotranspiration is required. Evapotranspiration rates for various types of vegetation have not been measured on Guam, but are considered roughly equivalent to tropical vegetation.

Air Quality. The ambient air of Guam remains relatively clean at all times, because prevailing winds carry clean air from the ocean across the island. Air pollution sources on Guam include: exhaust from automobiles; smoke and fumes from the burning of solid wastes; particulate dust from construction projects, parking lots, and roadsides; and emissions from power plants. Asbestos, another potential pollutant, is present in a few old buildings.

2.2.6 Biology and Ecology

Biology and ecology are important considerations in the Andersen AFB RI/FS activities. Most of the native terrestrial birds and mammals on Guam are considered threatened or endangered (DAWR, 1988), and parts of Andersen AFB provide critical habitats for several of these species. Also, many natural habitats and communities on Guam have been destabilized by the introduction of non-native species. The following section summarizes the considerations relating to threatened and endangered species, non-threatened or non-endangered wildlife, and other information on terrestrial ecological communities that occur on the island of Guam and may occur on parts of Andersen AFB. Because MARBO Annex is inland from the ocean, marine habitats and species are not considered.

Threatened or Endangered Species. Most of the native or endemic species of non-marine or non-migratory birds on Guam are listed as endangered either by the Government of Guam or by the U.S. Fish and Wildlife Service. All except four of these 15 species are either thought to be

extinct, extirpated from the island of Guam, or occur only as captive breeding populations. Small populations of the remaining species of native birds occur in much reduced ranges relative to those they once occupied. The ranges of three of these species do not presently include Andersen AFB. Mariana common moorhens are restricted to wetlands in central and southern Guam. Micronesian starlings are found primarily on Cocos Island, as well as a resident population on the developed part of the Anderson Main Base. Vanikoro swiftlets are known to occupy two caves in southern Guam. The currently known range of the Mariana crow is centered on Northwest Field of Andersen AFB and extends along the cliff-line adjacent to North Field (USAF, 1994). However, MARBO Annex is inland and disjunct from North and Northwest Fields, and is not within the current range of the Mariana crow.

The only native mammals on Guam are bats, and all of these species are listed as endangered by either the Government of Guam or by the U.S. Fish and Wildlife Service (USFWS) (DAWR, 1988). However, the records documenting the occurrence of a *Emballonura* sp. on Guam are based only on historical visual observations (Perez, 1972), and the endemic little Mariana fruit bat is believed to be extinct. The population of Mariana fruit bat on Guam was estimated to be 295-370 individuals in 1992 (DAWR, 1992b), and most of these bats are found among several roosts along the cliff-line in the vicinity of Pati Point, along the northeast shoreline of the North Field. However, MARBO Annex is inland and disjunct from North Field, and is not within the current range of the Mariana fruit bat.

One species of tree, the hayan lagu or *Serianthes nelsonii*, has been listed as an endangered species by the U.S. Fish and Wildlife Service. In addition, a second tree, ufa-halomtano or *Heritiera longipetiolata,* is listed by the Government of Guam as endangered (DAWR, 1988). The known distribution of both hayan lagu and ufa-halomtano is along the cliff-line adjacent to North and Northwest Fields of Andersen AFB. However, MARBO Annex is inland and disjunct from North and Northwest Fields, and is not within the current range of these two trees.

Critical Habitat for Threatened or Endangered Species. In 1991, the U.S. Fish and Wildlife Service proposed the designation of critical habitat on Guam for the little Mariana fruit bat,

Mariana fruit bat, Guam broadbill, Mariana crow, Guam Micronesian kingfisher, and Guam bridled white-eye (Federal Register, 1991). In northern Guam, this area includes the Anao Conservation Reserve along the coast east of Mt. Santa Rosa and much of the North Field and Northwest Field areas of Andersen AFB.

In 1992, the U.S. Fish and Wildlife Service proposed the establishment of a national wildlife refuge that would overlay most of the North Field and Northwest Field areas of Andersen AFB, excluding operational areas, the former U.S. Naval Facility at Ritidian Point, and certain Government of Guam lands (USFWS, 1993).

The MARBO Annex area of Andersen AFB is outside of both the proposed critical habitat area and the proposed national wildlife refuge. In addition, these sites are inland and disjunct from the currently known distributions of the Mariana crow, Mariana fruit bat, hayan lagu, and ufa-halomtano along the northern cliff-line of the island adjacent to North and Northwest Fields. No observations (i.e., direct or sign) of these species were made during the ecological habitat surveys of the sites (USAF, 1994), and these sites generally lack trees of the correct species and size that are used for roosting, nesting, or foraging by the Mariana crow and Mariana fruit bat. Therefore, it is unlikely that any threatened or endangered species would be associated with any of the MARBO Annex sites.

Other Vertebrate Terrestrial Wildlife. Only one species of non-marine or non-migratory bird on Guam is not considered endangered on Guam: the yellow bittern (*Ixobrychus sinensis*). This species is still counted regularly during roadside bird counts (DAWR, 1992a), and is considered common throughout the island. They are most abundant in the southern portion of the island where freshwater habitats are present.

All other non-marine or non-migratory birds commonly observed on Guam have been introduced by man. These birds include the black francolin, blue-breasted quail, rock dove, Philippine turtle-dove, black drongo, Eurasian tree sparrow , and chestnut mannikin. The black francolin, blue-breasted quail, and Philippine turtle-dove were apparently introduced to Guam as potential

game-species. The rock dove, Eurasian tree sparrow, chestnut mannikin, and black drongo are all introduced species that are generally most abundant in disturbed or urban habitats.

All species of mammals on Guam, excluding the bats, are introduced. Two species, the Guam (Sambar) deer (*Cervus unicolor mariannus*) and the wild (feral) pig (Sus scrofa) are generally free-ranging and are hunted on the island. Several species of rodents and a shrew have been introduced to the island (DAWR, 1988), but are generally associated with residential or urban areas. Other species of feral or semi-feral domestic animals may be common (i.e., feral dog, feral cat) or uncommon (i.e., domestic horse, domestic cow, Asiatic water buffalo, domestic goat), but are usually associated with human residences. While the deer and pigs are hunted as game-species, these two species are poorly controlled by hunting, and foraging by these species have caused damage to sensitive habitats on Andersen AFB and contribute to the rarity of the endangered plant species (Conry, 1989).

Seventeen species of terrestrial reptiles have been identified on the island of Guam. These species include five native and one introduced species of geckos, one introduced chameleon, six native and one introduced species of skinks, the introduced monitor lizard, and two species of introduced snakes. The historical introduction of at least six species, particularly the brown tree snake, and the continuing human development of natural habitats have apparently destabilized the resident herpetological communities. Rodda et al. (1991) report six species of skinks or geckos that have exhibited significant recent population decreases and range reductions island-wide on Guam.

The drastic decline of native forest birds species on Guam, particularly since 1960, has been largely attributed to predation by the introduced brown tree snake *(Boiga irregularis)* (Savidge, 1987; Conry, 1988a). This nocturnal, arboreal and terrestrial predator was apparently introduced to Guam from the Admiralty Islands, north of New Guinea. The snake is an effective nest predator, and the population declines in most forest birds paralleled the population increases in the brown tree snake.

Amphibians do not tolerate exposure to salt water and are not normally native to oceanic islands. However, two species have been introduced to Guam: the marine toad and the dwarf tree frog.

Terrestrial Ecological Habitats. A number of terrestrial ecological habitat types were previously identified on Andersen AFB in the environmental impact statement for the proposed Guam National Wildlife Refuge (USFWS, 1993). The following terrestrial habitat types were observed on or adjacent to the MARBO Annex:

- Second-growth Limestone Forest
- *Leucaena* (Tangantangan) Forest
- Former Coconut Plantation
- Active Base Area

Three additional ecological habitat types were identified during the ecological habitat surveys of the sites (USAF, 1994). These three habitats are described as "weed communities" that are characteristic of areas where there has been physical disturbance of the original vegetation:

- Mixed Shrub Forest
- Mixed Herbaceous Vegetation
- *Pennisetum purpureum* (Elephant Grass) Grassland

Each of the sites that were investigated as part of OU 3 were mosaics of the above terrestrial habitats, that seem to vary in relation to the extent and severity of past physical disturbance to the vegetation and soils.

2.2.7 Demographics

Population Density. Prior to the Spanish-American War in 1898, Spanish soldiers forced all of the natives of the neighboring islands to resettle on Guam. After WWII the population soared with the influx of American military personnel. The military presence still influences the demographics of the island with military populations dominating the native Guam population in both the 0-5 and 20-34 age groups (Guam Annual Economic Review, 1987). The population of Guam was 133,159 in 1990 (1990 Census). The geographic distribution of Guam's population

has shifted from the central to the northern region over the last 20 years. Approximately 47% of the total population resides in cities in northern Guam. The cities and their populations are as follows: Dededo (29,480), Tamuning (16,932), and Yigo (12,916) (1990 Census). The population on Andersen AFB currently includes approximately 2,900 military personnel and 1,100 civilians.

Age Distribution. The median age of residents on Guam is 25.0 years (1990 Census). Age distribution is as follows: 35.2%- 0-18 years, 60.9%- 18-64 years, and 3.9% are 65 years and older (1990 Census).

Household Income. The median household income for Guam in 1990 was $31,178 (1990 Census). The income for the northern and central regions of Guam was slightly higher than the overall median. Sixteen percent of Guam's population was below the poverty level.

Education Level. In 1990, approximately 73.3% of the population were high school graduates, and 17.5% were college graduates. The proportion of persons completing fewer than 8 years of elementary education was 13.9% (1990 Census).

Socioeconomics. The standard of living on Guam has improved since WW II. One of the factors responsible for this improvement has been the strengthening of Guam's economy. In 1989, 68% of the employed persons on the island were working in the private sector, 32% were employed in public positions, and only 2.1% were unemployed (Department of Commerce, 1989). Guam is in the midst of an economic boom. Strong and steady growth in the construction/development and tourism industries has fueled this sudden prosperity. Over 1 million tourists visited Guam in 1995 with most tourists coming from Japan. Tourism is expected to grow by at least 10% over the next few years.

Land Use. Most of the land in the northern portion of Guam is used by the Air Force and Naval operations on their respective installations. Private, nonmilitary residences are usually situated in areas that are accessible to Marine Drive, which loops through the central portion of the

region. Andersen AFB occupies the northern tip of Guam, with numerous annexes located throughout the northern half of the island. Small-scale agricultural crops produced on the island include pineapples, bananas, papayas, mangos, limes, avocados, and melons as well as cucumbers, green beans, peppers, squash, and eggplant.

Three principal areas account for most of the land on Guam under the control of the Andersen AFB Wing Commander. These are Andersen AFB, which includes the North Field, extending northeastward to Pati Point, and the Northwest Field, extending northward to Ritidian Point; the MARBO Annex, located 3.7 miles south-southwest of the Andersen AFB main gate; and the Harmon Annex, located on the west side of the island about 4 miles south of the Main Base. The Northern and Northwestern Field include approximately 24.5 square miles at the northern end of Guam, while the MARBO Annex (including the Andersen South housing area) occupies an area of 3.8 square miles on the southern slopes of the Yigo-Mofog Valley. The Harmon Annex, which has been included in Public Law (P.L.) 103-339 for transfer from the USAF to the Government of Guam, includes an area of approximately 2.5 square miles (1,601 acres).

The USAF controls other properties located on Guam, including Camp Edusa, Harmon Petroleum, Oil, and Lubricants (POL) Annex, Harmon Radio Beacon Annex, Tumon Tank Farm, Potts Junction Tank Farm, Mt. Santa Rosa Communications Station, and Barrigada Communications Station. The Camp Edusa, Harmon Radio Beacon Annex, and Harmon POL Annex have been included in PL 103-339 for transfer from the USAF to the Government of Guam. Other properties such as portions of the MARBO Annex are under consideration by the USAF to determine whether they are excess to the mission on Guam.

Two conservation reserves are situated in northern Guam; the Anao Conservation Reserve and Y-Piga Conservation Reserve. These areas are reserved for the preservation of natural habitats. The Anao Conservation Reserve, which is south of Anao Point on the east coast, occupies a strip of land approximately 1 mile long and 0.5 miles wide along the shoreline immediately east of Mount Santa Rosa. Y-Piga Conservation Reserve is located 0.5 miles due west of Andersen AFB's main gate and 0.75 miles southwest of Marine Drive on the southwest border of the Base.

The Y-Piga Conservation Reserve is approximately 0.25 miles wide and 1.0 mile long. Andersen AFB operations do not have any impact on these conservation areas.

2.3 SITE HISTORY AND ENFORCEMENT ACTIVITIES

In February 1992, the USEPA proposed to list Andersen AFB on the National Priorities List (NPL). Following the addition of Andersen AFB to the NPL on October 14, 1992, USAF entered into a Federal Facility Agreement (FFA) with USEPA and GEPA. The FFA establishes the process for involving Federal and Territorial regulatory agencies and the public in the Andersen AFB remedial response process. It also provides a procedural framework for developing, implementing, and monitoring response actions at Andersen AFB in accordance with CERCLA, SARA, the NCP, pertinent provisions of the Resource Conservation and Recovery Act of 1976 (RCRA), Hazardous and Solid Waste Act of 1982 (HSWA), and other applicable laws. A history of activities at each site that have led to the current status is included in Section 2.1

The DOD began the IRP in 1976 to identify, investigate, and mitigate environmental hazardous waste contamination that may be present at DOD facilities. Under Executive Order 12316, dated August 14, 1981, the military branches were directed to design their own program to remedy uncontrolled hazardous waste disposal sites in a manner consistent with the NCP and as established by CERCLA. In response to the Order, the DOD directed its branches to identify hazardous waste disposal sites to which they were contributors, and to comply with the environmental regulations at the installation level when implementing clean-up activities. The IRP was used as a model for the USAF IRP. The authority and objectives of the USAF programs were set forth in the Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5, dated December 11, 1981, which was implemented by the Air Force Headquarters in January 1982.

In response to changes in the NCP brought about by SARA, the USAF IRP was modified in November 1986 to improve continuity in the site investigation and remedial planning process for

USAF installations. In July 1987, Executive Order 12580 was signed, and the responsibility to conduct site investigations and remedial actions at Federal facilities was delegated to the Secretaries of Defense and Energy.

Prior to 1988, the basic USAF IRP consisted of the following four phases:

- Phase I - Initial Assessment/Records Search. This phase identified past disposal sites that might pose a hazard to public health or the environment and, therefore, required further action, such as a confirmation of an environmental hazard (Phase II). If a site required an immediate remedial action, the program could proceed directly to Phase IV.

- Phase II - Confirmation/Quantification Study. This phase was designated to define and quantify the extent of contamination, waste characteristics (when required by a regulatory agency), and sites or locations that required remedial actions. Stage 1 of Phase II was an initial assessment that was conducted to determine whether contamination was present at a site. Sites found to be contaminated may have required further investigation during subsequent stages of Phase II to assess the extent and significance of contamination. However, sites warranting immediate remedial action could be transferred to Phase IV. The research requirements identified during Phase II were included in Phase III.

- Phase III - Technology Base Development. This phase consisted of research and development to create new technologies for treating pollutants that otherwise were not technically or economically feasible to test. All of the research and development requirements, which could be identified at any time during the program, were addressed during Phase III.

- Phase IV - Remedial Action. This phase involved the preparation and implementation of the remedial action plan.

In 1988, the phased approach of the IRP was superseded by a method that more closely approximates the RI/FS guidelines in use by the USEPA. The new IRP format combines the Phase II - Confirmation/Quantification Study and the Phase IV - Remedial Action, and more closely parallels the CERCLA RI/FS process. This program modification provided the USAF the means to arrive at appropriate remedial actions in a timely and effective manner.

Phase I of the Andersen AFB IRP was completed in March 1985, and Phase II, Stage 1, was completed in January 1989. IRP Phase II, Stage 2 was completed in December 1991.

The FFA identified 39 sites to be investigated during the Andersen AFB RI/FS. Six of these sites are located on the MARBO Annex, and were investigated during the OU 3 RI. Although Landfill 29 was recommended for no further action at the conclusion of the IRP Phase II, Stage 1 investigation, it was investigated during the RI/FS because the recommendation for no further action was not approved by the regulatory agencies.

Phase I: During the Phase I records search, Waste Pile 7 was the only OU 3 site that was identified, and determined to be a potential source or migration pathway for contamination. Waste Pile 7 was among the 20 sites that were ranked using the USAF's Hazard Assessment Ranking Method (HARM) and was assigned a priority score of 86 (a score of 100 indicated the highest priority for future investigation), using the rating procedure described in the Installation Restoration Program Phase I: Records Search, Andersen AFB, Guam (ESE, 1985). Waste Pile 7 was recommended for field investigation in IRP Phase II. The other five OU 3 sites were added to the IRP during subsequent IRP investigation activities at Andersen AFB.

Phase II, Stage 1: In addition to Waste Pile 7, three additional OU 3 sites were discovered and investigated during Phase II, Stage 1: Waste Pile 6, Waste Pile 5 and Landfill 29.

The IRP Phase II, Stage 1 investigation included the following field activities:

- Aerial infrared photographs of the MARBO Annex were taken and anomalies were investigated;
- Shallow geophysical investigations (Electromagnetic Induction [EM] Surveys) were conducted at Waste Piles 5, 6, and 7, and Landfill 29 to verify anomalies identified in aerial photographs;
- Records review and identification of two additional sites.

The results of that investigation are presented in the IRP Phase II, Stage 1 Final Report (Battelle, 1989). Further investigation was recommended for Waste Piles 5, 6, and 7. In addition, the War Dog Borrow Pit and MARBO Laundry were added to the IRP during that stage. Additional

information regarding Phase II, Stage 1 activities is available in the report entitled "Installation Restoration Program Phase II Stage 1 - Confirmation/Quantification for Andersen Air Force Base, Guam" (Battelle, 1989).

Phase II, Stage 2: Waste Piles 5, 6, and 7, the War Dog Borrow Pit, and MARBO Laundry were investigated during Phase II, Stage 2. Landfill 29 was previously recommended for no further action and was not investigated during Stage 2. The IRP Phase II, Stage 2 investigation included shallow soil sampling at Waste Piles 5, 6, and 7, the War Dog Borrow Pit, and MARBO Laundry and some subsurface soil sampling at Waste Pile 7. The preliminary information obtained during the Phase II, Stage 2 work is presented in the report entitled "Remedial Investigation/Feasibility Study, Phase II Stage 2, RI/FS Andersen Air Force Base, Guam" (SAIC, 1991).

Phase II, Stage 3: Waste Piles 5, 6, and 7, the War Dog Borrow Pit, Landfill 29 and MARBO Laundry were investigated during this phase. The investigation included a topographic survey, site reconnaissance, electromagnetic survey, test excavations, soil gas sampling and soil sampling. Results of the investigation indicated that sufficient information had been collected to assess whether a health or ecological risk existed at any of the sites, and that no further sampling or field investigation was necessary. The results of the investigation are presented in the report entitled "Andersen Air Force Base Guam; Operable Unit 3 Remedial Investigation Report (OU 3 RI) (ICF, 1996)." Remedial alternatives for soil impacted by Air Force Activities are presented in the report entitled "Andersen Air Force Base Guam; Operable Unit 3 Focused Feasibility Study Report: (OU 3 FFS) (ICF, 1997a)."

2.4 HIGHLIGHTS OF COMMUNITY PARTICIPATION

Regulations under CERCLA require several community relations activities to occur before and at the completion of the ROD. These requirements are summarized in "Community Relations in Superfund: A Handbook" (USEPA, 1992). The required activities include: community interviews, a Community Relations Plan (CRP), an information repository and administrative record, Technical Assistance Grant (TAG) notification, public notice of the availability of the

Proposed Plan and RI/FS reports, public comment period and public meeting for the Proposed Plan, responsiveness summary to the Proposed Plan, pre-ROD significant changes, and public notice of selection of remedy. A summary of community activities to date is discussed below.

2.4.1 Community Relations Activities

Andersen AFB conducted interviews with 67 community members in 1992. On the basis of these interviews, it completed a CRP in 1993. The CRP was continually updated as the program evolved. In 1994, Anderson AFB established a Technical Review Committee (TRC) with representatives from: Government of Guam agencies, U.S. Congressional Delegate Underwood's office, the Guam Legislature, Mayor's offices, Guam Chamber of Commerce, USEPA, and the Water and Energy Research Institute at the University of Guam. In 1995, Andersen AFB converted the TRC to a Restoration Advisory Board (RAB) by adding representatives from the local community. The RAB meets quarterly and meetings are open to the public. The RAB serves as a focal point for environmental exchange between Andersen AFB and the local community. Andersen AFB has informed RAB members and the public of their option to apply for a TAG.

Andersen AFB published a notice of the availability of the RI report, FS report, and Proposed Plan for the MARBO Annex in the *Pacific Daily News* from October 8 through October 10, 1997. The notice announced the 30-day public comment period from Saturday, October 10 to Tuesday, November 10, 1997. A press release was also distributed to newspaper, radio, and television companies announcing the public meeting and public comment period. Andersen AFB made these reports, the Proposed Plan, and all IRP documents available at the Information Repositories and Administrative Record files shown below.

Installation Restoration Program
36 CES/CEVR
Unit 14007
Andersen AFB, Guam
APO AP 96543-4007
Telephone: (671) 366-5080
Contact: Marriane Miclat

Nieves M. Flores Memorial Library
254 Martyr Street
Agana, Guam 96910
Telephone: (671) 475-4751, 4752, 4753, or 4754
Contact: Christine Scott-Smith

University of Guam
Federal Documents Department
RFK Library, UOG Station
Mangilao, Guam 96923
Telephone: (671) 735-2321
Contact: Ken Carriveau

Andersen AFB distributed the Proposed Plan to all parties identified in the CRP including government officials, elected officials, media, private organizations, and interested community members. Andersen AFB presented a summary of proposed remedial alternatives and solicited comments on the Proposed Plan at a public meeting on Friday, October 24, 1997 at the Guam Hilton. Representatives from Andersen AFB, GEPA, and USEPA were present at the meeting to answer questions, and a transcript of this meeting was made available to the public. An official transcript of the meeting minutes is available in the Administrative Record.

Significant comments, criticisms, and modifications are included in the responsiveness summary of this document. A notice of this document's availability in the Administrative Record File will be published in the *Pacific Daily News* after it is signed.

2.5 SCOPE AND ROLE OF OPERABLE UNIT WITHIN THE SITE STRATEGY

Andersen AFB elected to use an Operable Unit or "OU" approach to manage the investigation and remediation of environmental conditions at the facility. The OUs described in the 1993 FFA were selected to:

- Expedite the completion of investigation activities;
- Evaluate sites with similar locations and potentially similar requirements as a group;
- Complete remedial design investigations at sites where closure decisions had been previously reached with the Government of Guam; and

- Provide a screening mechanism for evaluating newly or tentatively identified sites for inclusion in the RI/FS.

The site investigations and studies at the MARBO Annex were conducted under the designation of OU 2 and OU 3. OU 3 consists of all of the sites located on the MARBO Annex. This OU addresses soil and wastes associated with past activities. OU 2 consists of the groundwater in four subbasins (Yigo, Andersen, Agafa Gumas, and Finegayan) located under Andersen AFB properties (i.e., the North and Northwest Fields, MARBO Annex, and Harmon Annex). Most of the MARBO Annex is underlain by the Yigo subbasin (Figure 2-7). In 1996 (while the OU 2 RI/FS and OU 3 RI/FS were in progress at the MARBO Annex), the GEPA, USEPA Region IX, and Andersen AFB Remedial Project Managers (RPMs) reorganized the Andersen AFB OUs. As a result, the MARBO Annex soils and groundwater are now evaluated together as the MARBO Annex OU.

The MARBO Annex OU is one of four OUs at Andersen AFB, and the most advanced in the CERCLA regulatory process. Andersen AFB has selected a soil removal remedy for three sites at the MARBO Annex, thus addressing the principal threat of exposure to soils through removal. Andersen AFB has selected a soil cover for the fourth site (Waste Pile 7), addressing the principal threat of exposure to soils by mitigating exposure to soils which exceed health-based levels.

2.6 SUMMARY OF SITE CHARACTERISTICS

This section presents a summary of the contaminant screening process, with an overview of site contamination and potential routes of exposure.

2.6.1 Contaminant Screening Process

As described in the OU 3 RI (ICF, 1996), soil analytical data obtained from each disposal/spill area was compared to several screening criteria in order to determine whether or not detected compound(s) in a particular area warranted consideration for potential health or ecological risk.

The screening criteria are human health-risk based formulations which have been approved by Region IX USEPA and the GEPA; the application of these criteria to human health risk is addressed in Section 2.7. The cleanup performance standards are Region IX Residential Preliminary Remediation Goals (PRGs). For some inorganic compounds (i.e., metals) at the MARBO Annex, the background concentrations exceed the PRGs, in which case the soil analytical data are then compared to background metals' concentrations. The background metals' concentrations at Andersen AFB and the MARBO Annex are based on a statistical analysis of samples obtained during the OU 3 RI investigation. The comparison to background concentrations assesses whether the metals which were detected are naturally occurring in soil, or are potentially a byproduct of human activities. Lead concentrations in soil were compared to the USEPA's screening residential concentration of 400 mg/kg.

The first step in the screening process was a comparison of the maximum concentration of each detected constituent to the appropriate screening criteria. If the maximum concentration of a constituent exceeded the screening criteria, then the constituent was considered a Constituent of Potential Concern (COPC). The second step in the screening process was to assess the frequency of distribution of the COPC(s) at the site and/or disposal area. Potential exposure to site contaminants is a function of the frequency and distribution of the constituents in the soil, referred to as Exposure Point Concentrations (EPC). The EPC is calculated to quantify the Reasonable Maximum Exposure (RME) scenario, defined by the USEPA as the "highest exposure that is reasonably expected to occur at the site." The EPC was the lesser of the 95% Upper Confidence Limit (UCL) of the mean and the maximum concentration. In the case where there were only one, two or three samples obtained, the maximum concentration was utilized as the EPC. The third step was to compare the EPC to the screening criteria. If the EPC exceeded the screening criteria, the constituent was retained as a Constituent of Concern (COC), and carried in to the risk evaluation stage. In some cases, where a metal's EPC only slightly exceeded the screening criteria, the metal was not retained as a COC (ICF, 1996).

The following subsections summarize the constituents that were detected at each site, and those that were identified as COPCs and further screened to COCs. The maximum and minimum concentration of detected constituents at each site are shown on Table 2-1; the resulting COPCs

TABLE 2-1

SOIL ANALYSIS RANGE OF DETECTIONS
MARBO ANNEX
(Page 1 of 2)

Parameter	Units	Residential Soil PRG	Background Conc.	Site 20 - Waste Pile 7 Range of Detection	Site 22 - Waste Pile 6 Range of Detection	Site 23 - Waste Pile 5 Range of Detection	Site 24 - Landfill 29 Range of Detection	Site 37 - War Dog Borrow Pit Range of Detection	Site 38 - MARBO Laundry Range of Detection
Semivolatile Organic Compounds									
Acenaphthylene	µg/kg	None	--	ND	ND-580	ND	ND	ND	ND
Anthracene	µg/kg	19,000	--	ND	ND-760	ND	ND	ND	ND
Benzo(a)anthracene	µg/kg	610	--	ND	ND-1,900	ND	ND	ND	ND
Benzo(b)fluoranthene	µg/kg	610	--	ND	ND-32,000	ND	ND	ND	ND
Benzo(g,h,i)perylene	µg/kg	None	--	ND	ND-5,300	ND	ND	ND	ND
Benzo(a)pyrene	µg/kg	61	--	ND	ND-15,000	ND	ND	ND	ND
bis(2-Ethylhexyl)- phthalate	µg/kg	32,000	--	ND-4,000	ND-400	ND	ND	ND-38	ND
Butyl benzyl phthalate	µg/kg	13,000,000	--	ND	ND-4,800	ND	ND	ND-320	ND
Carbazole	µg/kg	22,000	--	ND	ND-610	ND	ND	ND	ND
Chrysene	µg/kg	24,000	--	ND	ND-4,800	ND	ND	ND	ND
Di-n-butyl phthalate	µg/kg	6,500,000	--	ND	ND	ND-280	ND	ND	ND
Fluoranthene	µg/kg	2,600,000	--	ND	ND-53,000	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	µg/kg	610	--	ND	ND-5,600	ND	ND	ND	ND
Phenanthrene	µg/kg	None	--	ND	ND-52,000	ND	ND	ND	ND
Pyrene	µg/kg	2,000,000	--	ND	ND-380	ND	ND	ND	ND
Pesticides and PCBs									
beta-BHC	µg/kg	250	--	ND	ND-0.89	NA	ND	ND	ND
alpha-Chlordane	µg/kg	340	--	ND-440	ND	NA	ND	ND	ND-330
gamma-Chlordane	µg/kg	340	--	ND-380	ND	NA	ND	ND	ND-690
4,4'-DDD	µg/kg	1,900	--	ND-1,900	ND-4.4	NA	ND	ND	ND-9.6
4,4'-DDE	µg/kg	1,300	--	170-26,000	ND-110	NA	ND	ND	ND-290
4,4'-DDT	µg/kg	1,300	--	42-13,000	ND-5.6	NA	ND	ND	ND-7.7
Dieldrin	µg/kg	28	--	ND-120	ND	NA	ND	ND	ND-6.7
Endosulfan I	µg/kg	None	--	ND	ND	NA	ND	ND	ND-0.96
Endrin	µg/kg	20,000	--	ND	ND-0.52	NA	ND	ND	ND-390
Heptachlor epoxide	µg/kg	49	--	ND	ND	NA	ND	ND	ND-12
Aroclor 1254	µg/kg	66	--	ND	ND	NA	ND	ND	21-26,000
Aroclor 1260	µg/kg	66	--	ND-4,400	ND	NA	ND	ND	ND
Inorganics and Moisture									
Cyanide, Total	mg/kg	1,300	1.47	ND-3.83	ND-0.543	ND-1.41	ND-0.573	ND-0.477	ND-0.845
Percent Water	%	None	--	2.7-41.6	11-31.6	7.6-61.5	12.6-31.6	7.3-26.4	12.6-34.2
Aluminum	mg/kg	77,000	173,500	15,600-605,000	4.32-158,000	1,950-201,000	2,730-172,000	194-105,000	11,900-175,000
Antimony	mg/kg	31	63	ND-91.3	ND-823	ND-115	ND-224	ND-24.7	ND-15
Barium	mg/kg	5,300	335	19.2-1,020	ND-311	14.5-628	3.89-56	0.46-33.2	7.51-55.4
Beryllium	mg/kg	0.14	3.34	ND-3.63	ND-3.9	0.156-3.43	ND-3.29	ND-2.91	0.189-4.21
Cadmium	mg/kg	38	6.5	ND-37	ND-183	ND-6.43	ND-11.3	ND-5.86	ND-28.4
Calcium	mg/kg	None	--	ND-395,000	123-383,000	2,630-314,000	25,300-367,000	50,900-410,000	20,900-303,000
Chromium	mg/kg	210	1,080	30-1,030	0.736-1,430	87.6-1,760	34.7-865	8.83-671	92.6-1,270

TABLE 2-1

SOIL ANALYSIS RANGE OF DETECTIONS
MARBO ANNEX
(Page 2 of 2)

Parameter	Units	Residential Soil PRG	Background Conc.	Site 20 - Waste Pile 7 Range of Detection	Site 22 - Waste Pile 6 Range of Detection	Site 23 - Waste Pile 5 Range of Detection	Site 24 - Landfill 29 Range of Detection	Site 37 - War Dog Borrow Pit Range of Detection	Site 38 - MARBO Laundry Range of Detection
Cobalt	mg/kg	4,600	29	ND-26.5	ND-29.5	ND-33.8	ND-36	ND-18.4	ND-21.2
Copper	mg/kg	2,800	72.2	26.2-15,200	ND-2,500	13.5-132	3.13-1,880	ND-35.6	8.42-52.6
Iron	mg/kg	None	--	3,200-158,000	71.2-498,000	15,900-330,000	1,800-129,000	195-69,500	8,550-122,000
Magnesium	mg/kg	None	--	159-3,610	10.5-3,630	70.1-2,930	938-3,460	841-3,040	1,330-2,600
Manganese	mg/kg	380	3,150	60.1-1,970	4.67-3,650	133-3,750	37.1-5,040	5.49-2,550	266-2,660
Nickel	mg/kg	1,500	242.5	ND-250	ND-269	23.8-292	ND-249	ND-143	13-192
Potassium	mg/kg	None	--	ND-393	ND-488	ND-416	ND-605	ND-146	ND-263
Silver	mg/kg	380	14.9	ND-10.5	ND-386	ND-4.39	ND-167	ND-3.81	ND
Sodium	mg/kg	None	--	48.6-469	ND-860	42.3-351	ND-256	18.2-121	72.9-158
Vanadium	mg/kg	540	206	17.9-181	ND-281	2.91-203	4.29-207	ND-111	15.1-198
Zinc	mg/kg	23,000	111	37.5-9,280	2.64-3,120	20.4-1,330	13.7-3,450	ND-402	33-188
Mercury	mg/kg	23	0.28	ND-2.19	ND-4.23	ND-5.14	ND-1.74	ND-0.139	0.0606-0.818
Thallium	mg/kg	6.13	1.42	ND-1.13	ND-1.84	ND-1.85	ND-1.53	ND-1.73	ND-1.74
Arsenic	mg/kg	0.38	62	ND-435	ND-93.3	4.14-138	0.378-71.3	ND-35.6	5.45-60.20
Lead	mg/kg	400	166	56.5-18,500	4.11-5,910	9.28-38,800	7.86-18,700	0.607-833	50.80-4,210
Volatile Organic Compounds									
Acetone	µg/kg	2,000,000	--	ND	ND-130	ND-440	ND-18	ND-9.2	NA
Benzene	µg/kg	1,400	--	ND	ND	ND-7.1	ND	ND	NA
2-Butanone (MEK)	µg/kg	8,700,000	--	ND	ND-92	ND-230	ND-11	ND-9.5	NA
Carbon disulfide	µg/kg	16,000	--	ND	ND	ND-17	ND	ND	NA
Chlorobenzene	µg/kg	160,000	--	ND	ND-0.82	ND	ND	ND	NA
Ethylbenzene	µg/kg	690,000	--	ND	ND-1.7	ND-220	ND	ND	NA
2-Hexanone	µg/kg	None	--	ND	ND	ND-840	ND-9.1	ND	NA
4-Methyl-2-pentanone (MIBK	µg/kg	5,200,000	--	ND	ND	ND-35	ND-10	ND	NA
Tetrachloroethene	µg/kg	7,000	--	ND	ND	ND-130	ND	ND	NA
Toluene	µg/kg	1,900,000	--	ND-5.7	ND-21	ND-220	ND-2.2	ND-3.7	NA
Xylenes (total)	µg/kg	990,000	--	ND	ND-4.6	ND-1,300	ND	ND	NA
NUTRIENTS									
Organic Carbon, Total	mg/kg	None	--	ND-26,300	NA	NA	NA	NA	NA
Organic Carbon, Total (%)	%	None	--	0.8-2.4	0.73-4	0.26-37.7	0.27-12.2	ND-5.4	NA
Nitrogen, Total Kjeldahl	mg/kg	None	--	1,570	5,170	4,930	8,810	1,160	NA
Phosphorus, Total as P	mg/kg	None	--	747	956	2,400	2,200	167	NA
pH (s.u.)	s.u.	None	--	7.70	7.4	7.20	7.1	7.50	NA
Total Petroleum Hydrocarbons									
Diesel	µg/kg	None	--	22,000-53,000	NA	NA	NA	NA	NA
Gasoline	µg/kg	None	--	ND	NA	NA	NA	NA	NA
JP4	µg/kg	None	--	27,000-54,000	NA	NA	NA	NA	NA

ND - Not Detected Above Reporting Limit
NA - Not Analyzed.
PRG - Preliminary Remediation Goal
-- - Background values calculated for organics and nutrient metals

and COCs for each site are shown on Table 2-2. Some of the sites have been subdivided into discrete spill/disposal areas. Only those spill/disposal areas where COCs have been identified are summarized in Table 2-2.

Site 20 (Waste Pile 7)

Waste Pile 7 is an abandoned quarry that is partially filled with waste (primarily construction/metal debris), and is covered with soil, vegetation, and scattered surficial debris. Several organic compounds were detected in the surface and subsurface samples. The detected organic compounds included pesticides (alpha-chlordane, gamma-chlordane, 4,4'-DDE, 4,4'-DDT, and dieldrin), Aroclor 1260, toluene, and bis(2-ethylhexyl)phthalate. The pesticide concentrations and frequency of detections indicated that these compounds are likely related to past site activities. Aroclor 1260 was found in only two samples but these concentrations are also likely related to past site activities because waste electrical components were observed at the site. Because toluene was not detected during the active soil gas surveys, and was detected infrequently and at very low levels, the presence of this volatile organic compound (VOC) in two subsurface soils is not believed to be significant. Bis(2-ethylhexyl)phthalate was detected in several samples, but these concentrations were qualified because the compound was also detected in blank samples, therefore the bis(2-ethylhexyl)phthalate detections are not believed to be significant. Inorganic analytes were detected in the surface and subsurface soils, however, based on the frequency and magnitude of detections these analytes (except lead), were considered to be representative of background conditions. A range of organic and inorganic detections for all samples is presented in Table 2-1.

Based on maximum concentrations, the COPCs at Site 7 were identified as 4-4'-DDE, 4-4'-DDT, Aroclor 1260, Dieldrin, alpha-chlordane, gamma-chlordane, aluminum, antimony, arsenic, copper, lead and beryllium. Based on the frequency and distribution of these constituents at Site 7, the COCs were identified as 4-4'-DDE, 4-4'-DDT, Aroclor 1260, Dieldrin, alpha-chlordane, gamma-chlordane and lead, estimated over an area of approximately two acres by 11-feet deep. A summary of COPCs, the calculated EPCs, and COCs are shown on Table 2-2.

TABLE 2-2

SITE CONSTITUENT SCREENING
(Page 1 of 2)

Site Name	Area	COPC[a]	Screening Criteria[b] (mg/kg) Background	PRG	Lead	EPC[c]	COC[d]
Site 20		4-4'-DDE	NA	1.3	NA	6.7	**4-4'-DDE**
(Waste Pile 7)		4-4'-DDT	NA	1.3	NA	6.2	**4-4'-DDT**
		Aroclor 1260	NA	0.066	NA	4.4	**Aroclor 1260**
		Dieldrin	NA	0.028	NA	0.12	**Dieldrin**
		Alpha-chlordane	NA	0.34	NA	0.44	**Alpha-chlordane**
		Gamma-chlordane	NA	0.34	NA	0.38	**Gamma-chlordane**
		Aluminum	173,500	77,000	NA	57,700	**Lead**
		Antimony	63	31	NA	43.9	
		Arsenic	62	0.38	NA	27.5	
		Copper	72	2,800	NA	365	
		Lead	166	400	400	3,604	
		Beryllium	3.34	0.14	NA	3.63	
Site 22	Car Battery	Antimony	63	31	NA	823	**Antimony**
(Waste Pile 6)	Area	Lead	166	400	400	5,910	**Lead**
	Radio Battery	Antimony	63	31	NA	71	**Antimony**
	Area	Cadmium	6.5	38	NA	41.9	**Cadmium**
		Lead	166	400	400	1,560	**Lead**
		Manganese	3,150	380	NA	3,190	
	Unknown Battery Area	Lead	166	400	400	3,410	**Lead**
	Asphalt Drum	Benzo(a)anthracene	NA	0.61	NA	1.9	**Benzo(a)anthracene**
	Pile	Benzo(a)pyrene	NA	0.061	NA	1.5	**Benzo(a)pyrene**
		Benzo(k)fluoranthene	NA	0.61	NA	7.6	**Benzo(a)fluoranthene**
		Arsenic	62	0.38	NA	73.8	**Arsenic**
		Beryllium	3.34	0.14	NA	3.5	**Chromium**
		Chromium	1,080	210	NA	1,270	**Lead**
		Lead	166	400	400	903	
	Roofing	Benzo(a)pyrene	NA	0.061	NA	15	**Benzo(a)pyrene**
	Material Pile	Benzo(a)fluoranthene	NA	0.61	NA	32	**Benzo(a)fluoranthene**
		Indeno(1,2,3-cd)pyrene	NA	0.61	NA	5.6	**Indeno(1,2,3-cd)pyrene**
		Arsenic	62	0.38	NA	65.8	
		Chromium	1,080	210	NA	1,120	
	Metal Debris	Cadmium	6.5	38	NA	183	**Cadmium**
	Pile	Silver	15	380	NA	386	
	Empty Drum	Beryllium	3.34	0.14	NA	3.66	**Chromium**
	Pile	Chromium	1,080	210	NA	1,290	
Site 23		Aluminum	173,500	77,000	NA	152,000	**No COCs[e]**
(Waste Pile 5)		Antimony	63	31	NA	16.25	
		Arsenic	62	0.38	NA	37.6	
		Beryllium	3.34	0.14	NA	2.62	
		Chromium	1,080	210	NA	720	
		Lead	166	400	400	79.7	
		Manganese	3,150	380	NA	1,715	

TABLE 2-2

SITE CONSTITUENT SCREENING
(Page 2 of 2)

Site Name	Area	COPC[a]	Screening Criteria[b] (mg/kg) Background	PRG	Lead	EPC[c]	COC[d]
Site 24 (Landfill 29)	Surface Drum Area	Antimony	63	313	NA	224	**Antimony**
		Arsenic	662	0.38	NA	67.3	**Lead**
		Lead	166	400	400	18,700	
	Subsurface Metal Area	Antimony	63	31	NA	123	**Antimony**
		Lead	166	400	400	1,120	**Lead**
Site 37 (War Dog Borrow Pit)		Lead	166	400	400	833	**Lead**[f]
Site 38 (MARBO Laundry)	Building Surroundings	Aroclor 1254	NA	0.066	NA	1.9	**Aroclor 1254**
		Gamma-chlordane	NA	0.34	NA	0.46	
		Aluminum	173,500	77,000	NA	117,011	
		Beryllium	3.34	0.14	NA	2.7	
		Chromium	1,080	210	NA	845	
	South Transformer	Aroclor 1254	NA	0.066	NA	26	**Aroclor 1254**
		Gamma-chlordane	NA	0.34	NA	0.69	**Lead**
		Lead	166	400	400	4,210	
	North Transformer	Aroclor 1254	NA	0.066	NA	1.5	**Aroclor 1254**
		Lead	166	400	400	3,080	**Lead**

Notes:

[a] COPC is Constituent of Potential Concern if maximum concentration exceeds screening criteria.

[b] Screening criteria based on health-risk based PRGs unless background metals' concentrations are higher. Lead screening criteria is 400 mg/kg per Region VI USEPA Lead Model.

[c] EPC is Exposure Point Concentration which is based on the 95% Upper Confidence Limit. This is considered a Reasonable Maximum Exposure Scenario based on the statistical concentration and distribution of contaminants throughout the disposal area.

[d] COC is Constituent of Concern if EPC exceeds screening criteria.

[e] EPC concentrations at Site 23 were below the screening criteria, thus no COCs were identified.

[f] Lead was detected above screening criteria in only one isolated sample at a depth of 11-feet below ground surface in a test pit. Due to the isolated nature of the sample, this was not considered a health risk.

Site 22 (Waste Pile 6)

The investigation of Waste Pile 6 identified surface debris but no buried wastes. Several pesticides were detected in the surface and subsurface soil samples collected from the three battery areas, including 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, endrin, and beta-BHC. The concentrations were relatively low and likely the result of routine pest control operations. Acetone, methyl ethyl ketone (MEK), and bis(2-ethylhexyl)phthalate were detected at low levels, and were believed to be insignificant. Organic compounds were also detected at the remaining four discrete/disposal areas. Site-related polycyclic aromatic hydrocarbons (PAHs) were detected under and around the Asphalt Drum Pile and Roofing Material Pile, as well as other VOCs (acetone, chlorobenzene, ethylbenzene, toluene, and total xylenes). The VOC concentrations were low and believed to be insignificant. Project inorganic analytes were detected in the surface and subsurface soils at each of the discrete/disposal areas. The concentrations of many of these analytes were considered to be representative of background conditions, however some of the inorganic detections were believed to be caused by the associated debris. A range of organic and inorganic detections for all samples is presented in Table 2-1.

Based on maximum concentrations, COPCs were identified at each discrete disposal area, including benzo(a)anthracene, benzo(a)pyrene, benzo(k)fluoranthene, indeno(1,2,3)pyrene, antimony, cadmium, arsenic, chromium, silver, beryllium, manganese and lead. Based on the frequency and distribution of these constituents within each disposal area, the COCs were identified as benzo(a)anthracene, benzo(b)pyrene, benzo(a)fluoranthene, indeno(1,2,3)pyrene, antimony, cadmium, arsenic, chromium, and lead, estimated at a total volume of approximately 130 cubic yards. A summary of COPCs for each disposal area at Site 6, the calculated EPCs, and COCs for each disposal area are shown on Table 2-2.

Site 23 (Waste Pile 5)

Waste Pile 5 is a trench-style landfill that consists of several large trench-like waste disposal cells containing mostly municipal waste. Several organic compounds were detected in some of the surface and subsurface samples. Acetone and toluene were detected in several subsurface soil samples at low levels. It is unlikely that these two VOCs are site-related, and the low-level presence of these VOCs is not believed to be significant. Other VOCs (benzene, MEK, methyl isobutyl ketone (MIBK), PCE, ethylbenzene, 2-hexanone, and carbon disulfide) were detected in two subsurface samples that contained organic wastes such as paint from a paint can and/or decomposing cardboard observed in a test pit. These detections are likely related to the debris, but the low concentrations and the minimal amount of organic waste suggests that the presence of these VOCs is not significant. The SVOC, di-n-butylphthalate was detected in one surface sample, and is not believed to be significant. Project inorganic analytes were detected in the surface and subsurface soils. Based on the frequency and magnitude of inorganic compound detections at Waste Pile 5, they were considered to be representative of background conditions. A range of organic and inorganic detections is presented in Table 2-1.

Based on maximum concentrations, the COPCs at Site 23 were identified as aluminum, antimony, arsenic, chromium, beryllium, manganese and lead. Based on the frequency and distribution of these constituents within each disposal area, there were no COCs identified at Site 23. A summary of COPCs for Site 23, and the calculated EPCs, are shown on Table 2-2.

Site 24 (Landfill 29)

Soil samples collected from the Surface Drum Area and Metal Debris Area in Landfill 29 contained several organic compounds (acetone, toluene, MEK, MIBK, and 2-hexanone). Because these VOCs were not detected during the active soil gas surveys, and were detected at very low levels, their presence in the subsurface soils is not believed to be significant. Project inorganic analytes detected in the surface and subsurface samples from these two areas were considered to be representative of background conditions. However, some of the inorganic

detections were believed to be caused by the associated debris. Samples were also collected from the area outside of the Surface Drum Area and Metal Debris Area. Organic compounds were not detected in these soil samples. Project inorganic analytes were detected in the soil samples, but all detections were less than screening levels. A range of organic and inorganic detections for all samples is presented in Table 2-1.

Based on maximum concentrations, the COPCs at the two disposal areas at Site 24 were identified as antimony, arsenic, and lead. Based on the frequency and distribution of these constituents within each disposal area, COCs were identified as antimony and lead, estimated at a total volume of approximately 35 cubic yards. A summary of COPCs for each disposal area at Site 24, the calculated EPCs, and COCs for each disposal area are shown on Table 2-2.

Site 37 (War Dog Borrow Pit)

The War Dog Borrow Pit is an area landfill that contains waste automobile parts. Organic compounds were detected in some of the subsurface samples. Acetone, toluene and MEK were detected in subsurface soil samples at low levels. It is unlikely that these VOCs are site-related, and the low-level presence of these VOCs is not believed to be significant. Bis(2-ethylhexyl)phthalate was detected in one subsurface soil sample and butyl benzyl phthalate was detected in two subsurface soil samples. However, these low level concentrations were not believed to be significant. Project inorganic analytes were detected in the surface and surface soils, however, the concentrations of these analytes (except lead) were considered to be representative of background conditions. A range of organic and inorganic detections is presented in Table 2-1.

Based on maximum concentrations, the only COPC identified at Site 37 was lead. Lead was retained as a COC but not considered a health risk due to the isolation of the sample. This is shown on Table 2-2. Of the 14 soil samples obtained at Site 37, lead was detected above the 400 mg/kg screening criteria only once (at 833 mg/kg). This was obtained from a depth of 11 feet bgs, from the bottom of a test pit.

Site 38 (MARBO Laundry)

The MARBO Laundry was a military laundry facility that was modified with the addition of a dry cleaning facility in 1970. Since 1974, the building has had other uses such as a storage facility for furniture. The building was renovated immediately before and during the OU 3 sampling. There were no SVOCs detected in the surface soil samples obtained from the MARBO Laundry. Pesticides and PCBs were detected in some of the samples, including alpha-chlordane, gamma chlordane, 4-4' DDE, Dieldrin, Endrin and Aroclor 1254. These compounds are considered representative of past activities. Project inorganic analytes were also detected and were considered representative of background conditions, with the exception of lead. A range of organic and inorganic detections is presented in Table 2-1.

Based on maximum concentrations, the COPCs at the Site 38 were identified as Aroclor 1254, gamma-chlordane, beryllium, chromium, lead and aluminum. Based on the frequency and distribution of these constituents, COCs were identified as Aroclor 1254 and lead, estimated at a total volume of approximately 135 cubic yards. A summary of COPCs for each disposal area at Site 38, the calculated EPCs, and COCs are shown on Table 2-2.

2.6.2 Potential Routes of Exposure

Practices at all sites have potentially affected surface and subsurface soil. Under present conditions, potential current receptors include a maintenance worker and trespasser. Under future conditions, potential residential receptors include a maintenance worker and trespasser, as well as a resident and construction worker. Present and future potential receptors are the same for all of the sites because current and future land use and accessibility are similar. Therefore, under current conditions, the most likely receptors at these sites are a maintenance worker and a trespasser. Each of these receptors would be exposed to surface soils. Under future conditions, potential exposure to site constituents is evaluated for a hypothetical construction worker. This receptor may be involved in the construction of a residential development, and could contact

subsurface soil via digging activities. Similarly, a hypothetical future resident may be exposed to subsurface soil that mixed with surface soil during digging activities.

Potential routes of exposure for all receptors include incidental ingestion and dermal contact of soils. Inhalation of soil particles is not considered to be a significant pathway for surface soils due to the nature of the constituents of concern. Under current conditions, wind-generation of particles is likely to be insignificant because all of the MARBO sites are extensively vegetated, or in the case of MARBO Laundry, paved. Airborne particles could be generated during digging activities, so inhalation of particulates may be a potential route of exposure for the construction worker for subsurface soils. This pathway would not be complete for a residential receptor because the ground in residential areas would be assumed to be covered by buildings, pavement, and vegetation. With regard to inhalation of volatiles at each site, active soil gas sampling failed to detect volatile constituents. In addition, detections of VOCs in subsurface soil samples at the sites were all below screening values. For these reasons, inhalation of VOCs was not evaluated as an exposure pathway.

2.7 SUMMARY OF SITE RISKS

Health Risk. The human health risk assessment was based on the guidance, *Region IX Preliminary Remediation Goals (PRGs) Second Half 1995* (USEPA, 1995), per the request of Region IX USEPA. The PRG's were selected as cleanup performance standards. Based on this approach, exposure point concentrations (EPCs) for site COCs were compared directly to Region IX PRGs for cancer or non-cancer effects. The exposure assumptions and toxicity assessment information, including cancer potency factors and non-cancer reference doses, used in the development of Region IX PRGs, are documented in the PRG guidance (USEPA, 1995). A copy of the this guidance is included in this ROD as Appendix A.

As noted in Section 2.6, background concentrations for inorganic chemicals and a lead concentration of 400 mg/kg were also utilized as screening criteria. After a COC was identified, following the screening process outlined in Section 2.6.1, the constituent was utilized for the

quantification or risk within each site and/or discrete source area. For COCs that exert carcinogenic effects, the chemical-specific EPC was divided by the cancer PRG. The resultant EPC/PRG ratio was then multiplied by 1 x 10^{-6} to derive a chemical-specific cancer risk. For chemicals that exert non-carcinogenic effects, the EPC was divided by the non-cancer PRG. The resultant EPC/PRG ratio is equal to the chemical-specific hazard index. Chemical-specific cancer risks and hazard indices were summed across all COCs to derive a total cumulative cancer risk and hazard index for each site and/or discrete source area.

The USEPA considers a risk of less than $1x10^{-6}$ (one in one million) to be protective of human health, and uses this value as the point of departure. The USEPA has developed the risk management range of $1x10^{-6}$ to $1x10^{-4}$ (one in ten thousand), as the target for managing cancer risk. The hazard index calculates potential non-cancer risks (e.g., skin lesions, decreased fertility, organ damage) that may be caused by exposure to a compound or group of compounds. For non cancer risk, the EPA has recommended a hazard index equal to or less than one. A hazard index number below one indicates that non-cancer health effects are not expected.

Based on this assessment, a human health risk was identified at one or more discrete disposal areas within Sites 20, 22, 24 and 38. There were no COCs identified at Site 23, and the isolated lead sample obtained from the bottom of a test pit at Site 37 was not considered a health risk. A summary of the estimated health risk for potential future residents at each site is shown below and on Table 2-3.

- A potential cancer risk of $2x10^{-4}$ and potential HI of 4 was identified at the 1.84-acre area of Site 20 (Waste Pile 7), based on elevated concentrations of PCBs, pesticides and lead;
- A potential cancer risk range of $2x10^{-12}$ to $5x10^{-4}$ and HI range of 0.01 to 27 was identified at the six disposal areas at Site 22 (Waste Pile 6), based on elevated concentrations of metals and PAHs;
- A potential cancer risk of $4x10^{-13}$ to $2x10^{-4}$, and an HI range of 4 to 10 was identified at the two disposal areas at Site 24 (Landfill 29), based on elevated metals concentrations;

TABLE 2-3

SITE-SPECIFIC CONSTITUENTS OF CONCERN AND ESTIMATED RISK

Site	Site Name	Area Description	Impacted Area (ft^2) and Volume (cubic yds)	Constituents of Concern (COC)	COC Concentration[a]	PRG or Background[b]	Hazard Index	Potential Cancer Risk	Lead Risk
20	Waste Pile 7	Buried Waste Area	Impacted area of 1.84 acres x 10.8' deep	4,4'-DDE	6.7	1.3	4	$2x10^{-4}$	Yes
				4,4'-DDT	6.2	1.3			
				Aroclor 1260	4.4	0.066			
				Dieldrin	0.12	0.028			
				alpha-Chlordane	0.44	0.34			
				gamma-Chlordane	0.38	0.34			
				Lead	3,604	400			
22	Waste Pile 6	Car Battery Area	7 ft^2 (0.2 cy)	Antimony	823	63	27	$2x10^{-11}$	Yes
				Lead	5,910	400			
	Waste Pile 6	Radio Battery Area	800 ft^2 (30 cy)	Antimony	71	63	12	$3x10^{-8}$	Yes
				Cadmium	41.9	38			
				Lead	1,560	400			
	Waste Pile 6	Unknown Battery Area	7 ft^2 (0.2 cy)	Lead	3,410	400	--	--	Yes
	Waste Pile 6	Asphalt Drum Pile	1,300 ft^2 (49 cy)	Benzo(a)anthracene	1.9	0.61	3	$3x10^{-4}$	Yes
				Benzo(a)pyrene	1.5	0.061			
				Benzo(b)fluoranthene	7.6	0.61			
				Arsenic	73.8	62.0			
				Chromium	1,270	1080			
				Lead	903	400			
	Waste Pile 6	Roofing Material Pile	50 ft^2 (3.5 cy)	Benzo(a)pyrene	15	0.061	3	$5x10^{-4}$	--
				Benzo(b)fluoranthene	32	0.61			
				Indeno(123cd)pyrene	5.6	0.61			
	Waste Pile 6	Metal Debris Pile	78 ft^2 (25 cy)	Cadmium	183	38	6	$1x10^{-7}$	--
	Waste Pile 6	Empty Drum Pile	70 ft^2 (12 cy)	Chromium	1290	1080	0.01	$3x10^{-5}$	Yes
24	Landfill 29	Surface Drum Area	175 ft^2 (31 cy)[c]	Antimony	224	63	10	$2x10^{-4}$	Yes
				Lead	18,700	400			
	Landfill 29	Subsurface Metal Area	52 ft^2 (4 cy)	Antimony	123	63	4	$4x10^{-11}$	Yes
				Lead	1,120	400			
38	MARBO Laundry	Building Surrounding	3,625 ft^2 (134 cy)	Aroclor 1254	1.9	0.066	3	$5x10^{-5}$	--
	MARBO Laundry	South Transformer	9 ft^2 (0.3 cy)	Aroclor 1254	26	0.066	19	$4x10^{-4}$	Yes
				Lead	4,210	400			
	MARBO Laundry	North Transformer	9 ft^2 (0.3 cy)	Aroclor 1254	1.5	0.066	1	$2x10^{-5}$	Yes
				Lead	3,080	400			

Notes:

[a] COC concentration is calculated as an Exposure Point Concentration (EPC) based on the distribution of contaminants throughout the site. The EPC is then used to calculate health risk. Concentrations are in mg/kg.

[b] Screening criteria listed is either the higher of PRG or background (background was higher than PRG 's for the metals arsenic, chromium and antimony), or the residential screening criteria for lead. Concentrations are in mg/kg.

[c] Includes volume of the drums, which may contain soil.

cy - cubic yards

(--) - Not Applicable either because COCs were not identified, or lead was not detected above screening levels.

- A potential cancer risk range of $5x10^{-5}$ to $4x10^{-4}$ and HI range of 1 to 19 was identified at the three disposal areas at Site 38 (MARBO Laundry), based on elevated concentrations of PCBs and metals.

The OU3 RI Report (ICF, 1996) identified uncertainties in the human health risk assessments for the above sites. The presence of uncertainty is inherent in the risk assessment process. Generally, uncertainties in risk assessment typically result from limitations in the available methods, information, and data used in the hazard identification, exposure assessment, toxicity assessment, and risk characterization steps. For many of the discrete source areas that were evaluated in the OU3 RI, the nature and extent of contamination was characterized by only one sample, collected in order to locate the highest concentrations of constituents. The maximum detected concentration, or 95 percent upper confidence limit (UCL), was assumed to represent the concentration (i.e., EPC) to which most people are exposed all of the time. Additionally, the calculated EPCs for several inorganic chemicals (e.g., aluminum, arsenic, beryllium, and chromium) were less than their respective background threshold levels. Furthermore, cancer risks and non-cancer HIs were calculated based on the use of integrated PRGs which assume that ingestion, dermal, and inhalation routes of exposure are complete; the only receptor identified in the conceptual site model with inhalation as a complete exposure pathway was a construction worker. The conclusions of the OU3 RI Report (ICF, 1996) indicate that most sources of uncertainty in the human health risk assessment erred on the protective side, and that the cancer risks and non-cancer HIs reported for Sites 20, 22, 24, and 38 most likely represent overestimates. Site-specific, tabulated summaries of the significant sources of uncertainty in the human health risk assessment are included in Appendix B of this ROD.

Based on the potential risks associated with Sites 20, 22, 24, and 38, actual or threatened releases of hazardous substances from these sites, if not addressed by implementing the response actions selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

Ecological Risk. The ecological risk assessments for the OU 3 sites were conducted in accordance with USEPA guidance (USEPA, 1989b). The objectives of the ecological risk assessments were to (ICF, 1996):

- Qualitatively characterize the potential ecological receptors that have been observed or could be present in terrestrial habitats on or adjacent to each of the sites;
- Qualitatively and quantitatively characterize the potential effects of the identified chemicals of potential concern in soils at each of the sites to potential ecological receptors;
- Assess potential exposures of ecological receptors to chemicals of concern in soils at each of the sites; and
- Characterize the risks associated with exposures of ecological receptors to the chemicals of potential concern in soils at each of the sites under current conditions.

The framework is conceptually similar to the approach used for the human health risk assessment but distinctive in its emphasis in three primary areas: 1) The ecological risk assessment considers effects beyond those on individuals of a single species and may examine effects on populations, communities, or ecosystems; 2) While there are general classes of ecological values that can be defined and should be considered in any ecological risk assessment, there is no single specific set of ecological resources to be protected that can be generally applied to every site, because of differences in the specific receptor habitats and their biological communities; 3) If needed, the ecological risk assessment can consider non-chemical as well as chemical stressors. However, no site-specific, non-chemical stressors were identified in association with these sites, therefore, only chemical stressors were evaluated. In accordance with this framework, an ecological risk assessment was conducted at five of the sites; (an ecological risk assessment was not conducted at the MARBO Laundry because the site is a building surrounded by maintained lawn and there are no ecological receptors).

Three receptors were evaluated based on species with the greatest exposure to COCs and their relevance to the overall ecosystems. These species were the blue-tailed skink (*Emoia*

caeruleocanda), terrestrial plants growing at the sites, and soil invertebrates (earthworms). Because there is little chemical toxicity data on reptiles, ecological risks to the blue-tailed skink were not quantified. Instead, qualitative observations were made of skinks during the ecological habitat survey for OU 3. Biologists counted the number of skinks observed while walking along paths cut at 50-foot intervals across each site. Populations of blue-tailed skinks were comparable between the sites under investigation and off-site locations with similar habitat. Risks to terrestrial plants were also evaluated based on the habitat survey. Vegetation was generally lush, and there were no significant observations of stressed vegetation.

Potential effects on earthworms were evaluated quantitatively, where COPCs were identified based on those chemicals that exceeded background threshold values in more than one or two samples, that had a frequency of detection greater than 5%, and that were not considered essential nutrients (e.g., calcium, iron, magnesium, potassium, and sodium).

Based on this assessment the ecological risk assessment did not identify any sites with a potential for adverse ecological effects based on the mean concentrations of the COPCs. Details of the ecological risk assessment are included in the OU 3 RI (ICF, 1996).

2.8 DESCRIPTION OF ALTERNATIVES

The remedial objective at each site is to reduce cancer risk to within or less than the target risk range of $1x10^{-6}$ to $1x10^{-4}$, and non cancer risks to a Hazard Index less than 1. The remedial action objective for lead contaminated soils is to reduce lead in the soil to concentrations less than 400 mg/kg. Four remedial alternatives were evaluated for the soil sites at the MARBO Annex. One of the four alternatives was then selected for each site after an analysis of site specific conditions. The four alternatives which were evaluated to address estimated health risk at each site are:

- No Action;
- Institutional Control;
- Soil Cover; and
- Soil Removal.

2.8.1 No Action (Alternative OU3-A)

The NCP and CERCLA, as amended, require the evaluation of a No Action alternative as a baseline for comparison with other remedial technologies. No Action represents a pure no action scenario. Under this alternative, no control or active treatment of the site soils or waste materials is performed. Potentially impacted media, therefore, remain at the site. The no action alternative does not decrease human health risks associated with exposure pathways at impacted sites.

2.8.2 Institutional Control (Alternative OU3-B)

Institutional Control utilizes specific controls to reduce the probability of exposure to impacted media at disposal/spill areas at a site, but no action with respect to site soils or waste materials is performed to remediate the constituents of concern. Institutional Control consists of the following components:

- Site Controls;
- Public Education; and
- Periodic Site Review.

Site Controls. Fencing would be constructed and signs would be used to restrict access to the site. To ensure that human health and the environment are protected in the future, deed restrictions will be implemented to place legal constraints on the future use of sites not used by the military.

Public Education. Public education programs would be developed to inform Andersen AFB personnel and local residents of potential risks. The public education effort under the Institutional Control alternative would include public meetings and presentations, press releases, and posting of signs where appropriate. This effort would be completed as part of the existing community relations program established at Andersen AFB, whose elements include a RAB. The RAB is comprised of members from the public who have the opportunity to read and

comment on IRP documents and provide input on project issues, and the maintenance of an Administrative Record.

Periodic Site Review. A review of site conditions would be conducted every 5 years. Periodic reviews include an evaluation of existing and new information along with an assessment of the future use of the site. The need for additional remedial measures would also be evaluated during the review.

2.8.3 Soil Cover (Alternative OU3-C)

The Soil Cover alternative consists of constructing a soil cover over impacted soils. By implementing this alternative, reductions in constituent toxicity, mobility, or volume are not achieved, but routes of exposure may be eliminated or reduced. The Soil Cover alternative consists of the following components, which include two actions coupled together: 1) constructing a soil cover over the impacted area; and 2) implementing the same components associated with the Institutional Control alternative (OU3-B):

- Site Controls;
- Public Education;
- Periodic Site Review;
- Site Preparation; and
- Soil Cover Construction.

Under this alternative, the site controls, public education, and periodic site reviews are the same as those described for Institutional Control.

Site Preparation. Prior to constructing the soil cover, soil stockpile areas for fill material will be designated, and appropriate construction support plans developed (e.g., a Health and Safety Plan, Quality Assurance Project Plan, and Environmental Response Plan). Air monitoring equipment will be set up around the excavation perimeter to monitor fugitive dust emissions. An equipment decontamination area will be constructed.

Soil Cover Construction. The purpose of the soil cover is to reduce exposure to contaminants. Grading of soils will utilize appropriate heavy construction equipment. Fill material will be stockpiled in designated areas prior to utilizing it as subgrade material. Random fill consisting of locally available crushed coral will be used to establish a subgrade layer up to 6 inches in depth that will be followed with a 12-inch soil layer consisting of clayey silt, obtained from borrow sources on the island. In addition, a final 6-inch soil layer will be used to accommodate the root system of the vegetation established over the covered area. A fence would be constructed around the site to prevent access during revegetation, and removed when revegetation is complete. Upon completion of site preparation and soil cover construction activities, the heavy equipment will be decontaminated and demobilized.

Approximately two acres of land will utilize the soil cover as the selected remedial alternative. Costs are discussed in Section 2.10.

2.8.4 Soil Removal (Alternative OU3-D)

The Soil Removal alternative consists of the excavation and disposal of impacted soil and has the following components:

- Public Meetings;
- Site Preparation;
- Soil and Debris Removal; and
- Disposal.

Under this alternative, the public meeting portion of the public education component of the Institutional Control alternative will be implemented. The site preparation activities identified for the Soil Cover alternative (OU3-C) are applicable. Soil/debris removal and disposal are discussed below.

Debris/Soil Removal. Debris from impacted disposal/spill areas will be removed. Soil with contaminant concentrations exceeding the screening criteria (either PRG's, background values for metals, or 400 mg/kg for lead) will be excavated from each impacted disposal/spill area

where a health risk has been identified. Utilizing the sample data and results from the OU 3 RI Report, an excavation plan will be developed to identify the soil/debris to be initially excavated and removed.

Excavated soil will be stockpiled within the site from which it was removed, for analytical testing to determine disposal location. Clean soils will be used as backfill, if needed, and the backfilled areas compacted and revegetated.

Confirmatory sampling will be performed after excavation to verify that soil exceeding the screening criteria is removed. Samples will be collected from the excavation area and analyzed for site constituents of concern. If analytical results demonstrate that the remaining soil still exceeds the criteria, additional soil removal and confirmatory sampling will be repeated until the appropriate levels are achieved or until the RPM's indicate that the soil removal activities should stop. A formally approved sampling and analysis plan (SAP) will be followed during performance of confirmatory sampling.

Disposal. Impacted soil and debris exceeding PRGs or background will be excavated, analyzed for COCs, and characterized as RCRA hazardous or non-hazardous wastes. The characterization includes assessing the two major categories which classify a soil waste as either hazardous or non-hazardous - listed and characteristic waste. Listed wastes include solid wastes that are generated by industry and assigned a specific work number, including: non-specific source "F" wastes (40 CFR 261.31); specific source "K" wastes (40 CFR 261.32) and commercial chemical "P" and "U" wastes (40 CFR 261.33). The soil and debris proposed for disposal at AAFB does not conform to either of these definitions. A characteristic waste is defined as a waste that is either ignitable (40 CFR 261.21), corrosive (40 CFR 261.22), reactive (40 CFR 261.23) or toxic (40 CFR 261.24). The determination of whether a solid waste is considered characteristically hazardous is made by analyzing the soil via the TCLP analysis. The TCLP analysis is designed to conservatively estimate the amount of contaminant that may leach out of the soil if the soil were exposed to environmental conditions where water (i.e., rainfall) could potentially percolate through the soil. If the results of the TCLP analysis indicate that either of the four characteristics

exceed acceptable levels (40 CFR 261, App. II), then the material is considered hazardous. Otherwise, the soil and debris is non-hazardous RCRA waste, and, equivalently, non-hazardous CERCLA waste (40 CRF 302.3).

Soil from each removal area exceeding industrial PRGs will be analyzed by TCLP analysis to determine if the soil will be regulated as RCRA hazardous or non-hazardous waste. If the soil is non-hazardous (i.e., below the TCLP criteria), it will be disposed of on site as solid waste at the Main Base landfill. If the soil is considered hazardous, based on the TCLP analysis, then it will be consolidated for off-island disposal. Other non-hazardous excavated debris (not specifically mentioned above) will also be disposed of in the Main Base landfill. As Land Disposal Restrictions are potentially applicable, this may affect the off-island disposition of some of the soil and debris that is characterized as RCRA hazardous waste.

Plastic battery casings, batteries, and asphalt debris will be properly disposed of or recycled according to applicable regulations. It is anticipated that asphalt debris will be recycled. That which is not recycled and is removed from impacted disposal/spill areas will be considered non-hazardous and disposed of or recycled as applicable. Batteries will be considered hazardous waste and disposed of accordingly.

Approximately 290 cubic yards will be removed as part of the Soil Removal Alternative. Costs are discussed in Section 2.10.

2.9 SUMMARY OF COMPARATIVE ANALYSIS ALTERNATIVES

The remedial alternatives developed were analyzed in detail using the nine evaluation criteria required by the NCP. These criteria are classified as threshold criteria, primary balancing criteria, and modifying criteria. Threshold criteria are:

1. Overall protection of human health and the environment
2. Compliance with Applicable Relevant and Appropriate Requirements (ARARs)

Primary balancing criteria are:

3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost

Modifying criteria are:

8. State/support agency acceptance
9. Community acceptance

The resulting strengths and weaknesses of the alternatives were then weighed to identify the alternative providing the best balance among the nine criteria. Because each of the sites is similar in nature with respect to contaminants, site layout, vegetation, and associated remedial alternatives, the comparison of the nine CERCLA criteria are applicable to each site. Table 2-4 summarizes this comparison. The cost of each alternative is site specific, which is discussed separately.

2.9.1 Overall Protection of Human Health and the Environment

This criterion is an overall assessment of whether each alternative provides adequate protection of human health and the environment. The evaluation focuses on a determination of the degree to which a specific alternative achieves adequate protection and describes the manner in which site risks are eliminated, reduced, or controlled through treatment, engineering, or institutional measures.

Institutional Control, Soil Cover, and Soil Disposal are expected to provide adequate protection of human health from soils presenting unacceptable risks. In addition, the site controls to be implemented with Institutional Control, Soil Cover, and Soil Disposal also provide adequate protection of human health for anticipated future land uses. Soil Disposal will reduce risks by excavating, removing, and properly disposing of the impacted material. Soil Cover will reduce

TABLE 2-4

COMPARISON OF SOIL ALTERNATIVES

Alternative	Compliance with ARARs[a]	Protection of Human Health and the Environment	Short-Term Effectiveness	Long-Term Effectiveness	Reduction of TMV[b]	Implementability	Cost[c]	Territorial Acceptance	Community Acceptance
No Action	Does not comply	Potential for future exposure remains.	Not Effective	Not Effective	No reduction in TMV	No Technical Limitations	Site Specific	Not Acceptable[d]	Not Acceptable[d]
Institutional Control	Exposure to soils exceeding chemical ARAR screening criteria is reduced.	Potential for future exposure slightly reduced.	Effective	Marginally effective.	No reduction in TMV	Easy Implementation	Site Specific	Not Acceptable[e]	Not Acceptable[e]
Soil Cover	Exposure to soils exceeding chemical ARAR screening criteria is eliminated or reduced.	Potential for future exposure reduced.	Effective	Effective	No reduction in TMV	Easy Implementation	Site Specific	Acceptable	Acceptable
Soil Removal	Soils exceeding chemical ARAR screening criteria excavated and removed.	Potential for future exposure significantly reduced.	Effective	Effective	No reduction in TMV	Easy Implementation	Site Specific	Acceptable	Acceptable

Notes:

[a] Action and Location specific ARARs are met for each alternative, where applicable. Site specific ARARs are further discussed separately for each site.

[b] TMV - Toxicity, mobility, and volume.

[c] Cost is discussed separately for each site.

[d] Not acceptable for the four sites above acceptable health risk (Waste Pile 5 and the War Dog Borrow Pit were within acceptable health risk range, therefore no further action was necessary).

[e] Not acceptable as a stand-alone alternative.

risks associated with impacted disposal/spill areas by covering the soils and implementing site controls to prevent exposure to the identified constituents of concern. Institutional Control will limit exposure pathways and may also reduce risks by controlling access to impacted disposal/spill areas, but there is more uncertainty in the protectiveness that this alternative will provide than there is for the Soil Cover and Soil Disposal alternatives. The No Further Action alternative does not provide adequate protection of human health at impacted disposal/spill areas where risks have been identified.

2.9.2 Compliance with ARARs

This threshold factor evaluates a remedial alternative's compliance with Federal and Territorial (Guam) ARARs as defined in CERCLA Section 121. Because ARARs vary with each site, the applicability of ARARs to the individual sites at the MARBO Annex is discussed in Section 2.10. The list of soil ARARs and To Be Considered criteria (TBCs) is shown on Table 2-5. Pursuant to Section 121 (d) CERCLA, as amended, the remedial actions must attain a degree of cleanup which assures protection of human health and the environment. In addition CERCLA requires that remedial actions meet standards, requirements, limitations, or criteria that are applicable or relevant and appropriate requirements (ARARs). ARARs are of three types: chemical-, action-, and location-specific. Identification and consideration of potential ARARs associated with a site and its remedial action is an ongoing process throughout site characterization and remediation.

An ARAR may be either "applicable" or "relevant and appropriate," but not both. The NCP defines "applicable" and "relevant and appropriate requirements" as follows:

> Applicable requirements means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. Only those state standards that are identified by a state in a timely manner, and that are more stringent than federal requirements, may be applicable.

TABLE 2-5

SUMMARY OF ARARs AND TBCs

Act or Authority	Issues and Requirements	Citation	Status	Rationale for Inclusion as ARAR or TBC	Affected Alternative
Federal Chemical-Specific ARARs					
USEPA Region IX Preliminary Remediation Goals (PRGs)	Health-based concentration goals for chemicals in environmental media: air, soil and water.	N/A	To Be Considered (TBC)	PRGs to be used as preliminary cleanup criteria for constituents of concern at sites with identified risks (if the PRG exceeds background).	No Action Institutional Control Soil Cover Soil Removal
Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)	Regulates the disposal and storage of pesticides and pesticide containers.	60 FR 32094; 6/19/95	Applicable (Site 20 only)	Pesticides identified as constituents of concern in some soils.	Soil Removal
Toxic Substances Control Act (TSCA)	Regulates wastes containing PCB constituents.	40 CFR 761	Applicable (Sites 20 and 38 only)	PCBs identified as constituents of concern in some soils.	Soil Removal
Federal Location-Specific ARARs					
Endangered Species Act	Promotes actions to conserve endangered species or habitat.	16 USC 1531; 50 CFR 200, 402	Applicable	Endangered species not on sites. Potential impacts of remedial actions will be assessed if migration occurs.	Soil Cover Soil Removal
Federal Action-Specific ARARs					
Clean Air Act (CAA)	National Ambient Air Quality Standards	40 CFR 50	Applicable	Emissions from remedial actions will be monitored.	Soil Cover Soil Removal
Hazardous Materials Transportation Act	DOT Regulations	40 CFR 100 - 177	Applicable	If soil or batteries are considered hazardous, requirements must be met for off-island disposal.	Soil Removal
Territorial (Guam) Specific ARARs					
Resource Conservation and Recovery Act (RCRA)	Identification and Listing of Hazardous Waste	40 CFR 261	Applicable	Soil and batteries will be tested to assess whether they are hazardous per this definition.	Soil Removal
	Standards Applicable to Generators of Hazardous Waste	40 CFR 262	Applicable	If soil or batteries are considered hazardous, these requirements must be met.	Soil Removal
	Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Applicable	If soil or batteries are considered hazardous, these requirements must be met for off-island disposal.	Soil Removal
	Land Disposal Restrictions	40 CFR 268	Applicable	If soil or batteries are considered hazardous, requirements must be met for off-island disposal.	Soil Removal
Guam Code Annotated (GCA)	Regulates solid waste collection and disposal	10 GCA, Chp 51.	Applicable	Addresses nonhazardous soil and debris disposed at Main Base landfill.	Soil Removal

> Relevant and appropriate requirements means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental, or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

In other words, a requirement is "applicable" when the remedial action or the circumstances at the site satisfy all of the jurisdictional prerequisites of that requirement. Relevant and appropriate requirements must be complied with to the same degree as if they were applicable, but there is more discretion in this determination and it is possible for only part of a requirement to be considered relevant and appropriate in a given case.

Where no promulgated standards exist for a given chemical or situation, nonpromulgated advisories and guidance ("to-be-considered" materials [TBCs]) issued by federal or state government may be used in determining the necessary level of cleanup for protection of human health or the environment. TBCs do not have the status of ARARs; however, in many circumstances they will be considered along with ARARs as part of the site risk assessment and may be used in determining the necessary level of cleanup.

Identification of ARARs and TBCs must be done on a site-specific basis. Neither CERCLA nor the NCP provide across-the-board standards for determining whether a particular remedy will effect an adequate cleanup at a particular site. Rather, the process recognizes that each site will have unique characteristics that must be evaluated and compared to those requirements that apply under the given circumstances.

2.9.2.1 Chemical-Specific ARARs. Chemical-specific ARARs include those environmental laws and regulations that regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These requirements generally set health- or risk-based concentration limits or discharge limits for specific hazardous substances (USEPA, 1989).

Chemical-specific ARARs are determined by identifying federal and state environmental statutes that are potentially applicable or relevant and appropriate to chemicals found at a particular site. Both ARARs and TBCs are subject to a site-specific risk assessment to ensure exposure levels are within acceptable limits for the protection of human health and other environmental receptors. In some cases, such as multiple exposure pathways or multiple contaminants, a risk assessment may indicate that an ARAR alone is not sufficiently protective and TBCs, including risk-based limits, will be used to establish more stringent clean-up requirements. The applicability of chemical-specific ARARs relative to specific site conditions is discussed in Section 2.10.

2.9.2.2 Location-Specific ARARs. As defined in the USEPA draft guidance (USEPA, 1988):

> "Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations. Some examples of special locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats."

Endangered species and their habitats are protected by the Endangered Species Act (ESA) (16 USC Sections 1531-1543). The proposed remedial actions could affect some species or their critical habitat during invasive installation. The mitigation efforts that would be performed prior to construction of any remedial alternative would entail inspection of the site for endangered species by qualified personnel, and selection of an alternative to eliminate or minimize impacts to these species if their presence is detected. The applicability of location-specific ARARs relative to specific site conditions is discussed in Section 2.10.

2.9.2.3 Action-Specific ARARs. Action-specific ARARs are restrictions that define acceptable treatment and disposal procedures for hazardous substances. These ARARs generally set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities related to management of hazardous substances or pollutants, such as RCRA regulations for waste treatment, storage, and disposal. These requirements are triggered by the

particular remedial activities that are selected to accomplish a remedy. The type and nature of these requirements is dependent upon the particular remedial or removal action taken at a site. Therefore, different actions or technologies are often subject to different action-specific ARARs. The applicability of action-specific ARARs relative to specific site conditions is discussed in Section 2.10.

2.9.3 Short-Term Effectiveness

Alternatives are evaluated with respect to their effects on human health and the environment during implementation of the remedial action. This evaluation addresses protection of site workers and the community during remedial actions, potential environmental impacts, and the time until remedial action objectives are achieved.

Because direct remedial actions will not be implemented as part of the Institutional Control alternative, increased short-term risks to workers, the community, and the environment during construction are expected to be minimal. Site controls would be implemented in approximately one month.

Increased short-term risks to workers, the community, and the environment during the implementation of the Soil Cover and Soil Removal alternatives are also expected to be minimal. A health and safety plan will be developed to mitigate risks from performing excavation, soil cover construction, and disposal activities. The health and safety plan will address items such as the use of personal protective equipment and the proper handling of impacted media. An air monitoring plan will be established to monitor the potential for off-site emissions of dusts. Dust control measures will be implemented as necessary. Site controls, construction activities, and the soil cover installation for the Soil Cover are expected to be completed in approximately 4 to 6 weeks.

2.9.4 Long-Term Effectiveness and Permanence

The purpose of this criterion is to assess the residual risk and the adequacy and reliability of controls associated with a particular alternative. The magnitude of risk resulting from the presence of untreated waste or treatment residuals is assessed with respect to the volume or concentration of residual contaminants.

The second component, adequacy and reliability of controls, assesses the containment systems and institutional controls in place to determine if they are sufficient to ensure that both human and environmental exposure is within protective levels. The long-term reliability of management controls to provide continued protection from residuals is also addressed with regard to (1) the potential need to replace technical components of the alternative, and (2) the potential exposure pathway and resulting risks should the remedial action need replacement.

Soil Removal will reduce risks associated with impacted disposal/spill areas to acceptable target risk levels (i.e., less than a cancer risk of $1.0x10^{-6}$ and noncancer hazard index of 1.0) by excavating and removing impacted material.

Soil Cover will reduce risks associated with disposal/spill areas by covering the soils to prevent exposure to the identified constituents of concern. By limiting the potential contact with elevated concentrations of constituents of concern in soils, the risks will be lowered to acceptable target risk levels (i.e., less than a cancer risk of $1.0x10^{-6}$ and noncancer hazard index of 1.0). Soil covers may have a long life if properly installed. The soil cover alternative restricts future use of the site to non-intrusive activities, thus reducing the potential economic value when compared to soil removal.

The use of Institutional Control will limit exposure pathways and, therefore, reduce risks to acceptable target risk levels by controlling access to impacted disposal/spill areas at OU 3 sites. Because impacted soils are left in place under this alternative, periodic site reviews will occur.

The long-term management activity associated with this alternative includes the performance of a periodic review.

2.9.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives are assessed to determine the extent to which they permanently reduce toxicity, mobility, and volume (TMV) of the contaminants posing the principal threats at a site. The specific factors considered in this assessment include:

- treatment or recycling process(es) of associated target contaminants and the amount of contaminants to be destroyed or treated;
- degree of expected reduction in the TMV and the degree to which treatment or recycling will be irreversible;
- type and quantity of treatment residuals expected to remain following treatment; and
- whether or not the alternative satisfies the statutory preference for treatment as a principal element.

None of the alternatives satisfy the statutory preference for using treatment to reduce toxicity, mobility, or volume of contaminants. However, each alternative will limit or eliminate the exposure pathways to the contaminants. Institutional Control will limit exposure through administrative and site controls, Soil Cover through the covering of impacted areas, and Soil Removal through the removal of impacted soil volume at identified disposal/spill areas at the soil sites.

2.9.6 Implementability

This criterion has three components: (1) technical feasibility, (2) administrative feasibility, and (3) availability of services and materials. Each alternative is assessed on the basis of factors within these three categories.

The assessment of the administrative feasibility of a particular remedial alternative is based on the number and complexity of activities needed to coordinate with other offices and regulatory agencies during preparation and implementation of the alternative. Factors that are considered in the assessment of technical feasibility include:

- potential for problems associated with construction and operation of an alternative;
- reliability of an alternative and its components;
- ease of undertaking additional remedial action, if needed; and
- ability to monitor the effectiveness of the remedy and evaluate the risks of exposure should monitoring be insufficient to detect a failure.

The availability of services and materials is to be considered. This includes such items as off-site treatment, storage or disposal capacity, equipment, and specialists.

Institutional Control is technically simple to implement. The establishment of deed restrictions would be implemented as a component for future nonmilitary land use where a restriction on the property title would be added during a land transfer. Installation of the temporary site fencing uses standard construction practices. The ability to keep potential squatters from locating to impacted sites involves periodic inspections. Fencing with the posting of signs will be a suitable deterrent while the site is being revegetated.

For the Soil Cover Alternative, the subgrade is established by using standard excavation and backfilling techniques, and is not expected to present technical implementability concerns. All components of this alternative use relatively common, uncomplicated construction procedures. The construction materials needed for the soil cover are available on Guam.

Soil Removal and light grading or backfilling are not expected to present technical implementability concerns for Soil Removal. The impacted site soils and debris are generally located near the ground surface. Special care will be necessary for the MARBO Laundry, where piping and other underground features may exist.

2.9.7 Cost

Both capital costs and operation and maintenance costs are considered for each alternative, with a target accuracy of -30 to +50 percent. Capital costs include both direct (e.g., equipment) and indirect (e.g., contingency allowances) costs. Costs are presented on a present-worth basis over a period of 30 years, with a discount rate of five percent. Detailed cost analysis is presented in the Focused FS (ICF, 1997a), and discussed on a site-specific basis in Section 2.10 of this document.

2.9.8 Federal and Territory Regulatory Acceptance

This assessment considers the technical and administrative issues and concerns the USEPA and Territory of Guam may have regarding each of the alternatives. The USEPA and Guam EPA both submitted comments to the draft version of this document prior to its going final. The comments ranged from editorial suggestions to comments concerning the implementation of the selected alternatives, particularly at Waste Pile 7. After addressing comments and concerns, the USEPA and Guam EPA are in concurrence and agreement with the selected soil alternatives. Their comments, and Andersen AFB's responses to those comments, are included as Appendix C.

2.9.9 Community Acceptance

This assessment evaluates the issues and concerns of the public regarding the proposed alternatives. A Proposed Plan and Community Relations Plan (CRP) was prepared to address community concerns and provide a forum for the exchange of information on the MARBO sites. As part of this plan, public participation is encouraged throughout all phases of design and remediation. After release of the Proposed Plan, which presented the same preferred remedies identified in the ROD, the community did not express significant objection during the public meeting or public comment period. Senator Brown noted concern pertaining to the connection between soil contamination at Waste Pile 7 and the groundwater. She also noted a concern over

land use restrictions on Waste Pile 7 after transfer to the Government of Guam. Responses to Senator Brown's concerns, and public comments, are included in Section 4.0.

2.10 THE SELECTED REMEDY

This section provides a description of the preferred alternative for addressing soil contamination at the MARBO Annex based on the detailed evaluation of alternatives presented in the Focused FS (ICF, 1997a). This section includes the basis for selection of a selected remedy, a description of the selected remedy, discussion of ARARs compliance, a discussion of the residual risk remaining after implementation of the selected remedy, and a cost analysis. The four remedial alternatives were evaluated for each site, and are summarized below. When compared to site-specific conditions, the selected remedy for each site balanced most effectively with the nine CERCLA criteria.

2.10.1 Site 20 (Waste Pile 7)

No Action, Institutional Control, and Soil Cover were evaluated for the Buried Waste Area at Waste Pile 7. Soil removal was considered impracticable at Waste Pile 7 as the level of effort and cost associated with soil removal outweighed the benefit of risk reduction, when compared to a soil cover.

Soil Cover is the Air Force selected remedy. Soil cover eliminates potential future health risk by cutting off direct exposure to the COCs through site controls and covering of the buried waste. Soil removal at Site 7 is impracticable where reduced risk of exposure can be attained via soil cover. Crushed coral will be used to establish a subgrade layer up to 6 inches in depth that will be followed with a 12-inch soil layer consisting of clayey silt. A final 6-inch soil layer will be used to accommodate the root system of the vegetation established over the covered area. A fence will be constructed around the site to prevent access during revegetation.

The cover will meet the objective of minimizing the potential for disturbing the wastes in the future and the potential for direct exposure. The cover will also minimize the potential future migration of contaminants to groundwater. To ensure that human health and the environment are protected in the future, land use at Waste Pile 7 is restricted to activities that cannot disrupt the physical or structural integrity of the cover. Restricted activities include trenching, excavation, or any other activity that could breach the cap. This restriction does not apply to maintenance activities conducted within the top 12 inches of the soil cap, to preserve or restore the physical or structural integrity of the cap. The Air Force shall place warning notices around the periphery of Waste Pile 7 stating that activities in the area are restricted.

The written concurrence of the FFA signatories is required before the Air Force takes any action at Waste Pile 7 that could disrupt the physical or structural nature of the cover. If any such action is proposed, the Air Force must provide FFA signatories with written notification of such proposed action. The notice shall include (i) an evaluation of the risk to human health and the environment, (ii) an evaluation of the need for any additional remedial action as a result of the proposed action, and (iii) a description of the changes necessary to the selected remedy for Waste Pile 7. The FFA signatories must provide written concurrence with the Air Force's evaluation of risk and proposal regarding any necessary changes in the remedial action, if required, before the Air Force can commence any action.

The Air Force shall notify the FFA signatories of any plan to lease or transfer Waste Pile 7 to a non-federal or federal entity, notify the transferee or leasee of the restrictions on activities at Waste Pile 7, and include the restriction in the transfer or lease. The Air Force shall comply with CERCLA 120(h)(3) in any such transfers.

The Andersen AFB Master Plan will be amended to incorporate the above-mentioned restrictions on activities at Waste Pile 7. The Master Plan amendments will also include language that describes the risk to human health and the environment that exists at Waste Pile 7, with reference to the OU 2 and OU 3 RI/FS and the MARBO Annex ROD; and will provide a legal description (metes and bounds) of the boundaries of Waste Pile 7. The language in the Master Plan will also include the title and dates of the above-listed documents and their storage location. The Air

Force will provide the FFA signatories with a copy of the amendments to the Master Plan reflecting the restrictions on Waste Pile 7.

The ARARs and TBCs determined to be pertinent to the remedial alternatives identified for Waste Pile 7 are shown on Table 2-6, along with estimated cost. The Federal Endangered Species Act was determined to be not relevant because no endangered species have been found at Waste Pile 7. However, the Act is retained as an ARAR which would be applicable if conditions at Waste Pile 7 are found to have changed during remediation activities. The Toxic Substances Control Act (TSCA) is not relevant to Waste Pile 7 because the alternatives considered do not involve the transportation, storage or disposal of PCBs (i.e., the activities regulated under TSCA). The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) regulates the sale, distribution and use of pesticides. As the remedy of Waste Pile 7 does not include any of these activities, and as there were no containers or drums of pesticides discovered at Waste Pile 7, FIFRA is not applicable. RCRA, the Hazardous Materials Transportation Act, and the Guam Code Annotated (GCA) regulating solid waste management are also not relevant because the alternatives evaluated for this site do not involve the transportation, storage, or disposal of solid or hazardous waste.

A qualitative evaluation of residual risk was performed, based on the selected remedy (i.e., soil cover). Under the selected remedy, impacted soils at Waste Pile 7 will be covered with 18 inches of clean fill soils and 6 inches of topsoil. The soil cover will effectively eliminate future exposures to site contaminants, by serving as a barrier to exposure pathways. Future exposures to site COCs will be eliminated, as long as the soil cover remains intact. As a result of the elimination of exposure pathways, there are no residual risks associated with the COCs that are being left in place. Therefore, the residual risks associated with this site are anticipated to be less than the cancer risk criterion of 1.0×10^{-6} and non-cancer HI of 1.0, as long as the soil cover remains intact.

Total 30-year present worth cost is estimated to be $629,800 in capital costs and $260,800 in O&M costs.

TABLE 2-6

SUMMARY OF REMEDIAL ALTERNATIVE COSTS AND ARARs

Site Name	Evaluated Alternative	Pertinent ARARs and Performance Standards Compliance	Total Cost (30-yr; 5% Discount Present Worth)[a]		Preferred Alternative
Site 20 - Waste Pile 7	No Action	PRGs—Not met.	No Action:	$0	**Soil Cover**
	Institutional Control	PRGs—Soil exposure reduced.	Inst. Control:	$222,900	
	Soil Cover	PRGs—Soil exposure eliminated. Clean Air Act—Will be met.	Soil Cover:	$890,600	
	Soil Removal	--[b]	Soil Removal:	--	
Site 22 - Waste Pile 6 (Battery Areas)	No Action	PRGs—Not met.	No Action:	$0	**Soil Removal**
	Institutional Control	--	Inst. Control:	--	
	Soil Cover	--	Soil Cover:	--	
	Soil Removal	PRGs—Will be met. RCRA 40 CFR 261, 262, 263, and 268 - Will be met, if necessary. Clean Air Act—Will be met. DOT 49 CFR—Will be met. Guam 10 GCA 51—Will be met.	Soil Removal:	$30,600	
Site 22 - Waste Pile 6 (Asphalt And Metal Pile Areas)	No Action	PRGs—Not met.	No Action:	$0	**Soil Removal**
	Institutional Control	--	Inst. Control:	--	
	Soil Cover	--	Soil Cover:	--	
	Soil Removal	PRGs—Will be met. RCRA 40 CFR 261, 262, 263, and 268 - Will be met, if necessary. Clean Air Act—Will be met. DOT 49 CFR—Will be met. Guam 10 GCA 51—Will be met.	Soil Removal:	$42,600	
Site 24 - Landfill 29	No Action	PRGs—Not met.	No Action:	$0	**Soil Removal**
	Institutional Control	--	Inst. Control:	--	
	Soil Cover	--	Soil Cover:	--	
	Soil Removal	PRGs—Will be met. RCRA 40 CFR 261, 262, 263, and 268 - Will be met, if necessary. Clean Air Act—Will be met. DOT 49 CFR—Will be met. Guam 10 GCA 51—Will be met.	Soil Removal:	$22,500	
Site 38 - MARBO Laundry	No Action	PRGs—Not met.	No Action:	$0	**Soil Removal**
	Institutional Control	--	Inst. Control:	--	
	Soil Cover	--	Soil Cover:	--	
	Soil Removal	PRGs—Will be met. RCRA 40 CFR 261, 262, 263, and 268 - Will be met, if necessary. Clean Air Act—Will be met. DOT 49 CFR—Will be met. Guam 10 GCA 51—Will be met. TSCA 40 CFR 761—Will be met.	Soil Removal:	$29,900	

Notes:

[a] Costs are based on ICF Technology Incorporated (ICF) Operable Unit 3 Focused Feasibility Study Report (OU 3 FFS). These criteria do not include costs for the disposal of soil which may be handled as hazardous waste.

[b] (--) Alternative not Evaluated.

2.10.2 Site 22 (Waste Pile 6)

Battery Areas. No Action and Soil Removal were evaluated for the three battery areas ("Car Battery Area," "Radio Battery Area," and "Unknown Battery Area") at Waste Pile 6. Institutional Control and Soil Cover are not applicable because these alternatives would restrict the future land use, whereas the removal of the small quantity of waste along with any impacted soil would allow unrestricted land use. Soil removal includes battery and soil removal.

Soil Removal is the Air Force selected remedy for the Battery Areas at Waste Pile 6. Soil removal can be readily implemented and will reduce health risk associated with soil exposure by removing the batteries and the soil which exceed residential PRGs/background.

The battery casings and batteries will be removed from each area. This includes approximately 6 plastic battery casings and 12 batteries. Soil exceeding residential PRGs/background will be excavated from each area. This includes an estimated 30 cubic yards (cy) of soil. The total impacted ground surface area was estimated at approximately 814 square feet, with an estimated depth of 1 foot. Soil and debris removal and confirmatory sampling will be performed after removal at Waste Pile 6. Pending TCLP analyses, impacted soil will either be disposed of as hazardous waste, off island, or as solid waste, at the Main Base landfill. It is anticipated that the batteries will be handled and disposed of as hazardous waste or recycled.

The ARARs and TBCs determined to be relevant to the remedial alternatives identified for the former Waste Pile 6 are shown on Table 2-6, along with estimated cost. The Federal Endangered Species Act was deemed not relevant for the same reasons described for Waste Pile 7. FIFRA and TSCA are not relevant because no pesticides or PCBs exceeding preliminary cleanup criteria were detected at this site. An evaluation of residual risk was performed for Waste Pile 6. Because this residual risk evaluation was performed for the entire site, the results are presented at the end of this section. Total present worth cost is estimated to be $30,600 in capital costs. This estimate is based on the assumptions presented in the OU 3 FFS (ICF, 1997), which assume that

all soil and debris would be disposed on site. Costs would be expected to increase should off-site disposal be required.

Asphalt and Metal Pile Areas. Similar to the battery areas, No Action and Soil Removal were evaluated for the remaining four disposal areas (the "Asphalt Drum Pile," "Roofing Material Pile," "Metal Debris Pile," and "Empty Drum Pile") at Waste Pile 6.

Soil Removal is the Air Force selected remedy for the Asphalt, Roofing, Empty Drum, and Metal Piles at Waste Pile 6. This alternative removes asphalt and contaminated soil which poses a potential health risk, and can be readily implemented. Soil removal includes the removal of 108 asphalt drums, the roofing material, the 16 empty drums and the other metal debris located in the shallow subsurface soil, as well as impacted soil exceeding the screening values. Based on the information presented in the OU 3 RI Report, the total impacted volume is estimated to be approximately 90 cubic yards of soil. Soil and debris removal and confirmatory sampling activities will be performed after removal. Asphalt in the drums will be recycled. It is anticipated that the asphalt in the 108 drums will be recycled to the extent possible and remaining debris will be disposed of as solid waste at the Andersen AFB landfill. Pending TCLP analyses, impacted soil will either be disposed of as hazardous waste, off island, or as solid waste, at the Main Base landfill.

The ARARs and TBCs determined to be pertinent to the remedial alternatives identified for the former Waste Pile 6 are shown on Table 2-6, along with estimated cost. The Federal Endangered Species Act was deemed not pertinent for the same reasons described for Waste Pile 7. FIFRA and TSCA are not pertinent because no pesticides or PCBs exceeding preliminary cleanup criteria were detected at this site.

A quantitative evaluation of residual risk was performed for Waste Pile 6, based on the selected remedy (i.e., soil removal). Supporting data and the residual risk calculations for the evaluation are presented in Appendix B. Waste Pile 6 currently contains seven discrete areas of impacted soil, as previously described. Under the selected remedy, impacted soils exceeding screening

criteria (i.e., residential PRGs) will be excavated and removed from all seven areas of Waste Pile 6. Areas of the site containing COCs at concentrations less than the screening criteria will remain in place. As part of the residual risk evaluation, the analytical data (i.e., soil boring results) associated with the areas remaining in place were evaluated, and the residual COCs and their maximum concentrations were identified. The maximum concentrations of residual COCs were included in calculations of residual risk for potential future residential and industrial receptors. For the potential future residential receptor, the presence of residual COCs in site soils is associated with a cancer risk of 1.0×10^{-7} and a non-cancer HI of 0.20. For the potential future industrial receptor, the presence of residual COCs in site soils is associated with a cancer risk of 3.0×10^{-8} and a non-cancer HI of 0.01. Therefore, residual risk for Waste Pile 6 has been reduced to an acceptable cancer risk criterion of 1.0×10^{-6} and non-cancer HI of 1.0.

Total present worth cost is estimated to be $42,600 (all capital costs). Costs would be expected to increase should off-site disposal be required.

2.10.3 Site 24 (Landfill 29)

No Action and Soil Removal were evaluated for the Surface Drum Area and Subsurface Metal Area at Landfill 29. Institutional Control and Soil Cover are not applicable because these alternatives would restrict the future land use of Landfill 29, whereas the removal of the small quantity of waste along with any impacted soil would allow unrestricted land use. Soil removal includes the removal of drums, metal debris, and soil.

Soil Removal is the Air Force selected remedy for the surface drum area and the subsurface debris area at Landfill 29. The soil removal alternative removes contaminated soil which poses a potential health risk, and can be readily implemented. The 86 drums scattered across the surface of the "Surface Drum Area" and the metal debris in the "Subsurface Metal Area" will be removed, in addition to the soil exceeding screening criteria. Based on the information presented in the OU 3 RI Report, these removal activities include approximately 35 cubic yards of material (inclusive of 25 cubic yards of drums partially filled with soil, and 10 cubic yards of impacted

soil). The estimated soil depth in the surface drum area is 1 foot, and 2 feet in the subsurface debris area. Soil removal and confirmatory sampling activities will be performed after removal. Pending TCLP analyses, impacted soil will either be disposed of as hazardous waste, off island, or as solid waste, at the Main Base landfill. It is anticipated that remaining debris will be disposed of as solid waste at the Andersen AFB landfill.

The ARARs and TBCs determined to be pertinent to the remedial alternatives identified for the Landfill 29 are shown on Table 2-6, along with estimated cost. The Federal Endangered Species Act was deemed not relevant for the same reasons described for Waste Pile 7. FIFRA and TSCA are not relevant because no pesticides or PCBs exceeding preliminary cleanup criteria were detected at this site.

A quantitative evaluation of residual risk was performed, based on the selected remedy (i.e., soil removal). Supporting data and the residual risk calculations for the evaluation are presented in Appendix B. Landfill 29 currently contains two discrete areas of impacted soil, as previously described. Under the selected remedy, impacted soils exceeding screening criteria will be excavated and removed from both areas of Landfill 29. Areas of the site containing COCs at concentrations less than the screening criteria will remain in place. The analytical data (i.e., soil boring results) associated with the areas remaining in place were evaluated, and the residual COCs and their maximum concentrations were identified. The maximum concentrations of residual COCs were included in calculations of the residual HI for potential future residential and industrial receptors; residual cancer risks were not calculated because no carcinogenic COCs will remain post-remediation. For the potential future residential receptor, the presence of residual COCs in site soils is associated with a non-cancer HI of 0.00001. For the potential future industrial receptor, the presence of residual COCs in site soils is associated with a non-cancer HI of 0.000003. Therefore, residual risks for Landfill 29 are anticipated to be less than the cancer risk criterion of 1.0×10^{-6}, and residual hazards are less than the target non-cancer HI of 1.0.

Total present worth cost is estimated to be $22,500 (all capital costs). This estimate is based on the assumptions presented in the OU 3 FFS (ICF, 1997), which assumes that all soil and debris

would be disposed on site. Costs would be expected to increase should off-site disposal be required.

2.10.4 Site 38 (MARBO Laundry)

No Action and Soil Removal were evaluated for the MARBO Laundry. Soil Cover would restrict the future land use of MARBO Laundry, whereas the removal of the small quantity of impacted soil would allow unrestricted land use at MARBO Laundry.

Soil Removal is the Air Force selected remedy at the MARBO Laundry. This alternative removes contaminated soil which poses a potential health risk, and can be readily implemented. Affected soil exceeding screening criteria will be excavated and removed from each area. The OU 3 RI samples were located about 2–3 feet from the edge of the building and the east parking area. Analysis of soil samples showed the presence of PCBs at the two former transformer locations, and near the edge of the building, but not in other samples taken further away from the building. Therefore, soils containing elevated levels of Aroclor 1254 are assumed to extend laterally about 5 feet out from the north and south side of the building and at a location near the east side of the east parking area. The total impacted ground surface area is estimated to be approximately 3,600 square feet, with an estimated depth of 1 foot. Total impacted soil is estimated to be approximately 135 cubic yards. Confirmatory sampling will be performed after removal. Pending TCLP analyses, impacted soil will either be disposed of as hazardous waste, off island, or as solid waste, at the Andersen AFB active landfill.

The ARARs and TBCs determined to be pertinent to the remedial alternatives identified for the former Waste Pile 6 are shown on Table 2-6, along with estimated cost. As shown in Table 2-6, TSCA may be a pertinent ARAR if PCB concentrations exceed 50 ppm. Transportation and disposal of the soil and debris will conform with appropriate TSCA regulations under this scenario, however PCB concentrations at the MARBO Laundry have been well below 50 ppm. The Federal Endangered Species Act was deemed not relevant for the same reasons described for

Waste Pile 7. FIFRA is not relevant because there are no pesticides which exceed the preliminary cleanup criteria.

A qualitative evaluation of residual risk was performed, based on the selected remedy (i.e., soil removal). Under the selected remedy, all areas of MARBO Laundry containing impacted soils exceeding screening criteria will be excavated and removed from the site. Since all areas of the site containing impacted soils exceeding screening criteria will be excavated and removed, it is anticipated that residual risks will be less than the cancer risk criterion of $1.0x10^{-6}$ and non-cancer HI of 1.0.

Total present worth cost is estimated to be $29,900 (all capital costs). This estimate is based on the assumptions presented in the OU 3 FFS (ICF, 1997), which assumes that all soil and debris would be disposed on site. Costs would be expected to increase should off-site disposal be required.

2.11 STATUTORY DETERMINATIONS

The selected remedy for soils satisfies most of the statutory requirements of Section 121 of CERCLA, as amended by SARA, per the following mandates:

- The selected remedies are protective of human health and the environment, will decrease site risks, and will not create short-term risk nor have cross-media consequences;
- The selected remedies comply with federal and state requirements that are applicable or relevant and appropriate to the remedial action such as chemical-specific ARARs, chemical-specific clean-up standards, and action-specific ARARs;
- The selected remedies are cost-effective, and address the nine CERCLA evaluation criteria through remediation of the contaminated soil in a reasonable period of time.

2.11.1 Protection of Human Health and the Environment

Soil removal will eliminate site COCs and the soil cover will eliminate and/or reduce exposure to site COCs. The implementation of these remedies will not create any short-term risk nor any negative cross-media aspects. The residual risk remaining at each site after implementation of the selected remedy is discussed in Section 2.10.

2.11.2 Compliance with ARARs

All ARARs will be met by the selected remedies. The remedies will achieve compliance with chemical-specific clean-up standards. Action-specific ARARs will be met during soil removal and construction of the cover. None of the anticipated actions or construction is expected to have a detrimental impact on endangered species.

2.11.3 Cost Effectiveness

The USEPA, the USAF, and the Territory of Guam believe that the selected remedies address the nine criteria of the NCP and provide overall effectiveness in relation to their cost.

2.11.4 Utilization of Permanent Solution and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Possible

The selected remedy uses a permanent solution and treatment technology to the maximum extent practicable. Due to the small amount of impacted soil, and the cost and effort associated with a permanent solution or an alternative treatment technology, permanent solutions and treatment technologies were deemed impracticable. Thus, the selected remedies do not meet the statutory requirements to utilize permanent solutions and treatment technologies. The selected remedies were made public in the Proposal Plan (October 1997) and presented at a public meeting (October 1997), with no significant objections from either the public or the Territory of Guam.

2.11.5 Preference for Treatment as a Principle Element

As noted above, due to the small amount of impacted soil, a treatment technology is considered impracticable.

2.12 DOCUMENTATION OF SIGNIFICANT CHANGES

There are no significant changes in this ROD from the Proposed Plan. The Proposed Plan and ROD vary from the OU 3 FFS with regard to soil and debris disposal, however. The OU 3 FFS proposed disposal of soil and most of the debris from Waste Pile 6, Landfill 29 and MARBO Laundry to Waste Pile 7, where the accumulated soil and debris would be placed under the Waste Pile 7 soil cover. Current remedial alternatives recommend conducting a TCLP leachate analysis on soils where COC concentrations exceed industrial PRGs to determine whether the soil is hazardous. If the soil is considered hazardous, then it will be consolidated and disposed of off-island in a licensed hazardous waste facility. If the soil is considered non-hazardous, then it will be disposed of on-site in the Main Base landfill. Though the removal/disposal technology does not change for Waste Pile 6, Landfill 29 and the MARBO Laundry, the cost will increase should off site disposal be necessary.

3.0 DECISION SUMMARY FOR GROUNDWATER

This decision summary provides a description of groundwater conditions at the MARBO Annex, including legal and public involvement issues, site risks, remedial alternatives and the rationale for selection, and how the selected remedy satisfies statutory requirements. The more general issues that were discussed in Section 2.0 will not be repeated here, such as site description, regional setting, physiography, meteorology, demography and land use, hydrology, hydrogeology, and water use.

3.1 SITE HISTORY AND ENFORCEMENT ACTIVITIES

Groundwater related field activities followed the same phased approach as described in Section 2.2, beginning with Phase II.

Phase II, Stage 1 was completed in 1989. This included groundwater monitoring well installation, groundwater elevation monitoring, and sampling and analysis. A total of five IRP monitoring wells were installed and sampled during this phase, including: IRP-1, IRP-2, IRP-8, IRP-10 and IRP-12. Each of the wells were installed in the upper portion of the freshwater lens (i.e., shallow wells), in the Mariana/Barrigada limestone formations. The wells were sampled in May, August, and October 1987. Three discrete rounds of water level measurements were made; one in June and two in October 1987. Groundwater samples were also collected from four off-site production wells (M-6, D-1, D-4 and D-5) and eight on-site Air Force production wells (MW-1 through MW-3 and MW-5 through MW-9). The results of this investigation are presented in the IRP Phase II, Stage 1 Final Report (Battelle, 1989). The wells which were sampled are summarized on Table 3-1.

Phase II, Stage 2 was completed in December 1991. Three additional IRP monitoring wells were installed and sampled during this stage of work, including IRP-14, IRP-15 and IRP-16. IRP-14 was installed to monitor the groundwater in the vicinity of the MARBO Laundry, and IRP-15 and 16 were installed to monitor groundwater in the vicinity of Site 20. Groundwater sampling

TABLE 3-1

HISTORICAL MONITORING AND PRODUCTION WELL SAMPLING
MARBO ANNEX
(Page 1 of 2)

	Well ID	Phase II Stage 1 Rounds 1,2, and 3	Phase II Stage 2 Rounds 1 and 2	Phase II Stage 3 Rounds 1 and 2	Phase III Stage 3 Rounds 1 and 2
IRP Wells	1	X	X	X	X
	2	X	X	X	X
	8	X	X	X	X
	10	X	X	X	X
	12	X	X	X	X
	14		X	X	X
	15		X	X	X
	16		X	X	X
	23			X	X
	24(deep)			X	X
	25			X	X
	26			X	X
	27			X	X
	28			X	X
	29(deep)			X	X
	30			X	X
	31(deep)			X	X
	32B			X	X
	33(deep)			X	X
	34			X	X
	35(deep)			X	X
Production Wells	MW-1	X	X	X	X
	MW-2	X	X	X	X
	MW-3	X	X	X	X
	MW-5	X	X	X	X
	MW-6	X	X	X	X
	MW-7	X	X	X	X
	MW-8	X	X	X	X
	MW-9	X	X	X	X
	D-1	X	X	X	X
	D-2				X
	D-3				X
	D-4	X	X	X	X
	D-5	X	X	X	X
	D-14				X
	Y-2		X	X	X
	Y-4				X
	Y-5				X
	Y-6				X
	M-5				X
	M-6	X			X
	M-7				X
	M-15				X

TABLE 3-1

HISTORICAL MONITORING AND PRODUCTION WELL SAMPLING
MARBO ANNEX
(Page 2 of 2)

	Well ID	Phase II Stage 1 Rounds 1,2, and 3	Phase II Stage 2 Rounds 1 and 2	Phase II Stage 3 Rounds 1 and 2	Phase III Stage 3 Rounds 1 and 2
Monitoring Wells	GPA-1(deep)			X[a]	X
	GPA-2(deep)			X[a]	X

[a] Wells sampled during Phase II, Stage 3, Round 2 (February 1996) only.

Phase II, Stage 1: Three monitoring rounds, completed in 1989
Phase II, Stage 2: Two monitoring rounds, completed in 1991
Phase II, Stage 3: Four monitoring rounds - Round 1 - Oct/Nov 1995
Round 2 - Feb/Mar 1996
Round 3 - Oct/Nov 1996
Round 4 - Apr/May 1997

and measurements were conducted on the same wells as Stage 1, with the addition of IRP-14, 15 and 16 and Y-2. Production well M-6 was not sampled during this stage of work. Groundwater samples and depth-to-water measurements were conducted twice during this stage, from April through August 1989. The results of this investigation are presented in the IRP Phase II, Stage 2 Final Report (SAIC, 1991). The wells which were sampled are summarized on Table 3-1.

Phase II, Stage 3 (Groundwater Monitoring Rounds 1 and 2) took place at the MARBO Annex from November 1995 to February 1996, including: borehole drilling, lithologic well logging, borehole condition logging and downhole geophysics, and monitoring well installation. The groundwater investigation consisted of water level measurements and groundwater sampling. A total of thirteen monitoring wells were installed, IRP-23 through IRP-35. Monitoring wells IRP-24, 29, 31, 33 and 35 were installed approximately 90 feet below the top of the groundwater surface (deep wells) in order to monitor water quality at the base of the freshwater lens. The remaining IRP wells were installed at the top of the freshwater lens (shallow wells). Groundwater sampling and measurements were conducted during October-November 1995 and February-March 1996. A total of 21 IRP wells, twelve production wells, and two monitoring wells (GPA-1 and GPA-2 [both sampled February 1996 only]) were sampled, as shown on Table 3-1. Continuous groundwater level measurements were also conducted on some of the IRP wells and production wells from December 1994 through October 1995. The results and assessment of the groundwater sampling (through Phase II, Stage 3, Rounds 1 and 2) are presented in ICF's March 1997 final report entitled "Andersen Air Force Base Guam; Operable Unit 2 MARBO Annex Remedial Investigation Report" (OU 2 RI) (ICF, 1997b). The wells which were sampled are summarized on Table 3-1.

Phase II, Stage 3 (Groundwater Monitoring Rounds 3 and 4) encompasses the remaining groundwater sampling and measurement activities that are included in this document. Two additional rounds of groundwater sampling were conducted in October-November 1996 and April-May 1997, and utilized in the OU 2 FFS in order to assess longer-term trends. A total of 21 IRP wells (same as Stage 3), 22 production wells and two monitoring wells (GPA-1 and GPA-2) were sampled, as shown on Table 3-1. Groundwater sampling and analysis will continue at the MARBO Annex until at least four complete rounds of sampling have been

conducted. Any additional sampling at the MARBO Annex would be conducted in order to meet long-term sampling requirements which are proposed as part of the OU 2 FFS (discussed in Sections 3.4 and 3.5 of this document). Remedial alternatives for groundwater impacted by Air Force Activities are presented in the "Andersen Air Force Base Guam; MARBO Annex Operable Unit 2 Focused Feasibility Study Report" (OU 2 FFS) (EA and Montgomery Watson, 1997). The results of the October-November 1996 and April-May 1997 sampling (for TCE and PCE only) are included in the OU 2 FFS.

BioEnvironmental Engineering Groundwater Monitoring. The Air Force production wells have been monitored since 1978 under the Safe Drinking Water Act for PCE and TCE, along with other required analytes under this Act.

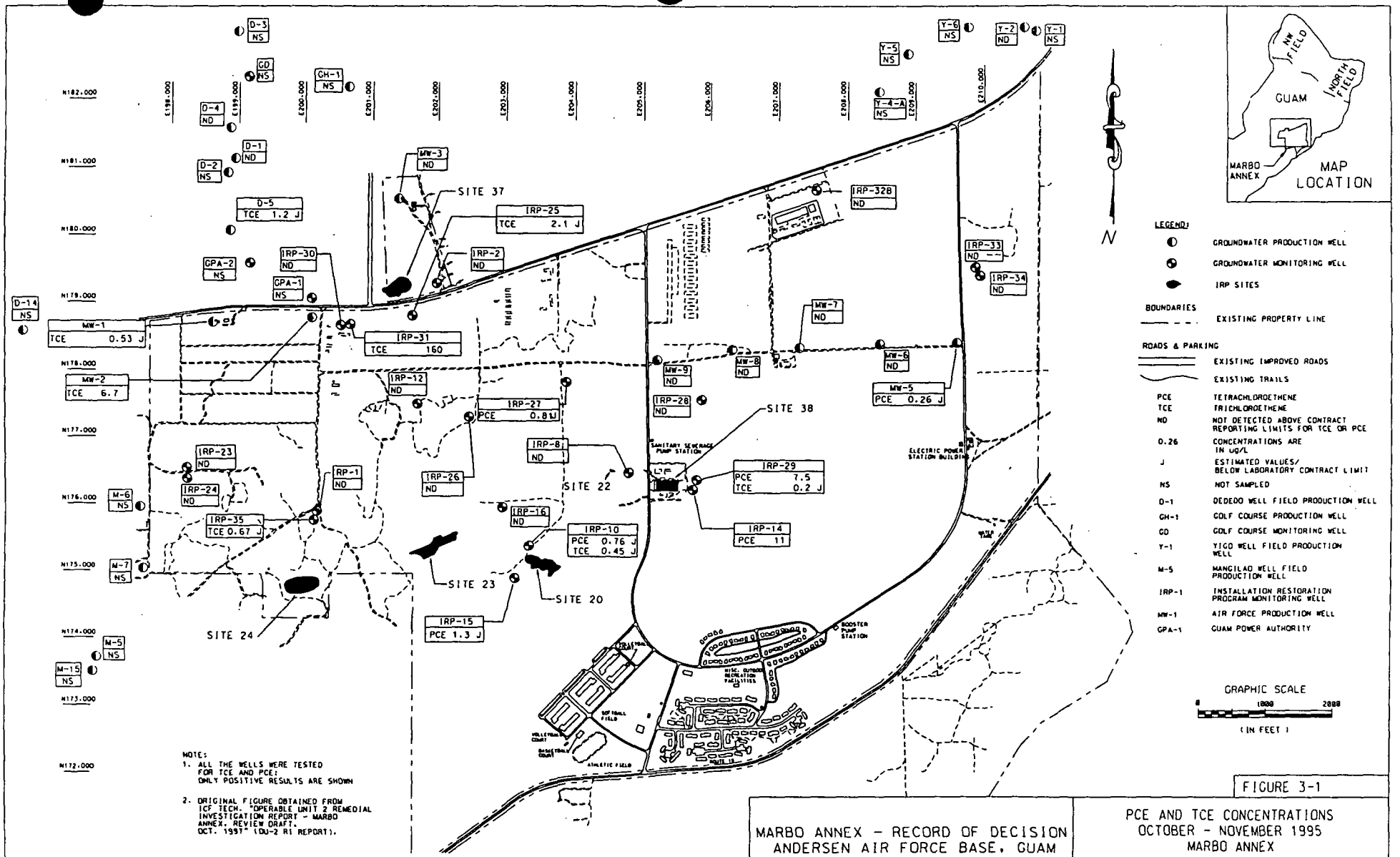
3.2 SUMMARY OF SITE CHARACTERISTICS

This section presents an overview of site contamination and potential routes of exposure posed by conditions at the site.

3.2.1 Nature and Extent of TCE and PCE

Two COCs were identified in the OU 2 RI, trichloroethylene (TCE) and tetrachloroethylene (PCE), based primarily on their frequency of detection above Federal Maximum Contaminant Levels (MCLs). The Federal MCL for both TCE and PCE is 5 micrograms per liter (µg/L). Analytical results for the four most recent sampling events are shown on Figures 3-1 through 3-4. Figure 3-5 shows the maximum TCE and PCE concentrations historically detected at the MARBO Annex, and Figure 3-6 shows representative groundwater contours for the MARBO Annex. Tables showing historical maximum, minimum and recent TCE and PCE concentrations are also included as Tables 3-2 and 3-3, respectively.

A total of 29 wells which are presently installed within the property boundary of the MARBO Annex were monitored for TCE and PCE (as well as other constituents required either under



NOTE:
1. ALL THE WELLS WERE TESTED FOR TCE AND PCE; ONLY POSITIVE RESULTS ARE SHOWN
2. ORIGINAL FIGURE OBTAINED FROM ICF TECH. "OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT - MARBO ANNEX, REVIEW DRAFT, OCT. 1997" (OU-2 RI REPORT).

PLOT SCALE: 1=1300

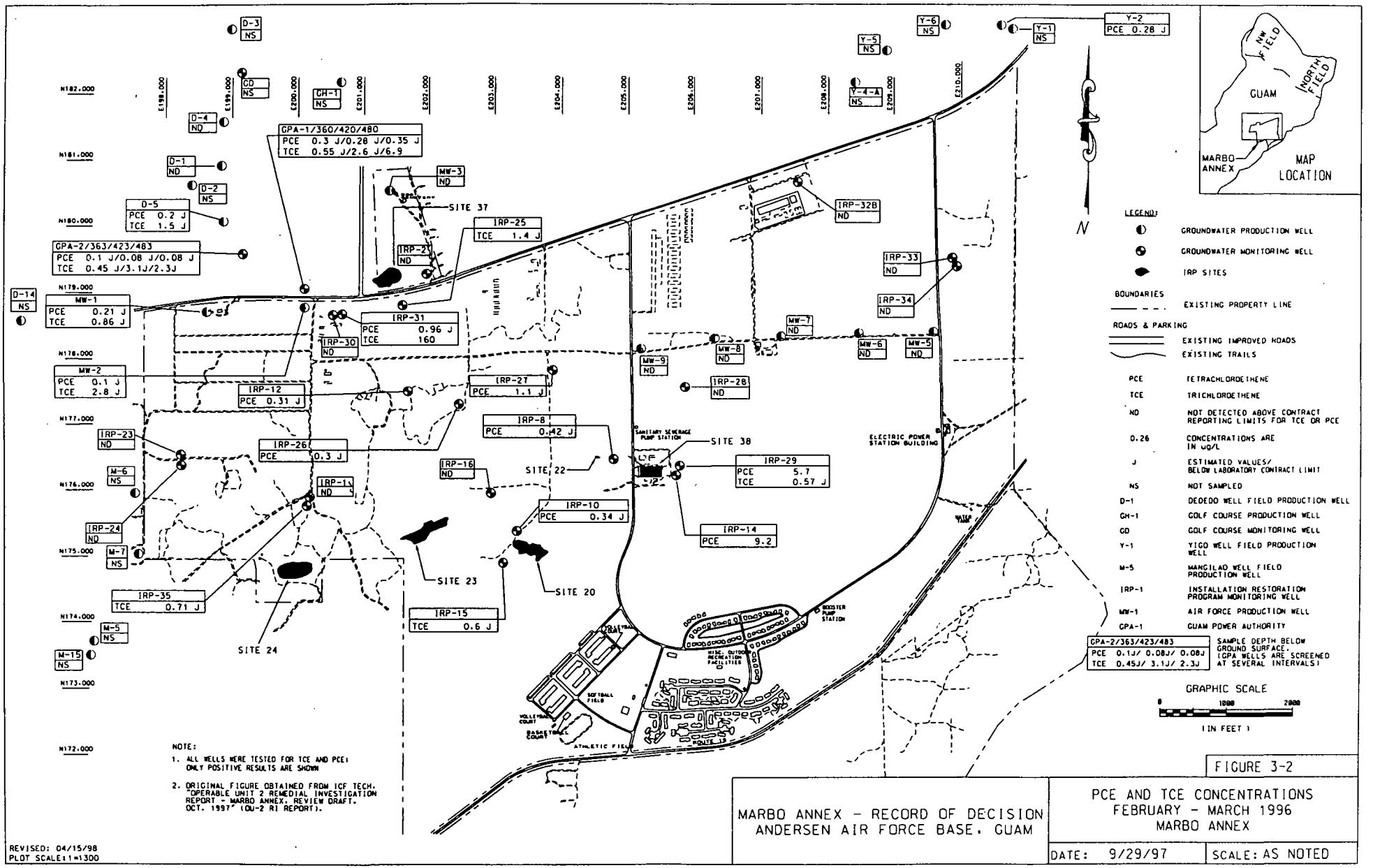
FIGURE 3-1

MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM

PCE AND TCE CONCENTRATIONS
OCTOBER - NOVEMBER 1995
MARBO ANNEX

DATE: 9/29/97

SCALE: AS NOTED


GPA-1/360/420/480
PCE 0.3 J/0.28 J/0.35 J
TCE 0.55 J/2.6 J/6.9
D-5
PCE 0.2 J
TCE 1.5 J
GPA-2/363/423/483
PCE 0.1 J/0.08 J/0.08 J
TCE 0.45 J/3.1J/2.3J
MW-1
PCE 0.21 J
TCE 0.86 J
MW-2
PCE 0.1 J
TCE 2.8 J
IRP-31
PCE 0.96 J
TCE 160
IRP-25
TCE 1.4 J
IRP-12
PCE 0.31 J
IRP-27
PCE 1.1 J
IRP-8
PCE 0.42 J
IRP-26
PCE 0.3 J
IRP-29
PCE 5.7
TCE 0.57 J
IRP-14
PCE 9.2
IRP-10
PCE 0.34 J
IRP-35
TCE 0.71 J
IRP-15
TCE 0.6 J
Y-2
PCE 0.28 J
SITE 37
SITE 38
SITE 22
SITE 23
SITE 20
SITE 24
SANITARY SEWERAGE PUMP STATION
ELECTRIC POWER STATION BUILDING
BOOSTER PUMP STATION
MISC. OUTDOOR RECREATION FACILITIES
SOFTBALL FIELD
VOLLEYBALL COURT
BASKETBALL COURT
ATHLETIC FIELD
ROUTE 13
GUAM
NW FIELD
NORTH FIELD
MARBO ANNEX
MAP LOCATION
N
LEGEND:
GROUNDWATER PRODUCTION WELL
GROUNDWATER MONITORING WELL
IRP SITES
BOUNDARIES
EXISTING PROPERTY LINE
ROADS & PARKING
EXISTING IMPROVED ROADS
EXISTING TRAILS
PCE TETRACHLOROETHENE
TCE TRICHLOROETHENE
ND NOT DETECTED ABOVE CONTRACT REPORTING LIMITS FOR TCE OR PCE
0.26 CONCENTRATIONS ARE IN ug/L
J ESTIMATED VALUES/ BELOW LABORATORY CONTRACT LIMIT
NS NOT SAMPLED
D-1 DEDEDO WELL FIELD PRODUCTION WELL
GH-1 GOLF COURSE PRODUCTION WELL
GD GOLF COURSE MONITORING WELL
Y-1 YIGO WELL FIELD PRODUCTION WELL
M-5 MANGILAO WELL FIELD PRODUCTION WELL
IRP-1 INSTALLATION RESTORATION PROGRAM MONITORING WELL
MW-1 AIR FORCE PRODUCTION WELL
GPA-1 GUAM POWER AUTHORITY
GPA-2/363/423/483
PCE 0.1J/ 0.08J/ 0.08J
TCE 0.45J/ 3.1J/ 2.3J
SAMPLE DEPTH BELOW GROUND SURFACE. (GPA WELLS ARE SCREENED AT SEVERAL INTERVALS)
GRAPHIC SCALE
0 1000 2000
(IN FEET)
NOTE:
1. ALL WELLS WERE TESTED FOR TCE AND PCE; ONLY POSITIVE RESULTS ARE SHOWN
2. ORIGINAL FIGURE OBTAINED FROM ICF TECH. "OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT - MARBO ANNEX, REVIEW DRAFT, OCT. 1997" (OU-2 RI REPORT).
REVISED: 04/15/98
PLOT SCALE:1=1300
FIGURE 3-2
MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM
PCE AND TCE CONCENTRATIONS
FEBRUARY - MARCH 1996
MARBO ANNEX
DATE: 9/29/97
SCALE: AS NOTED

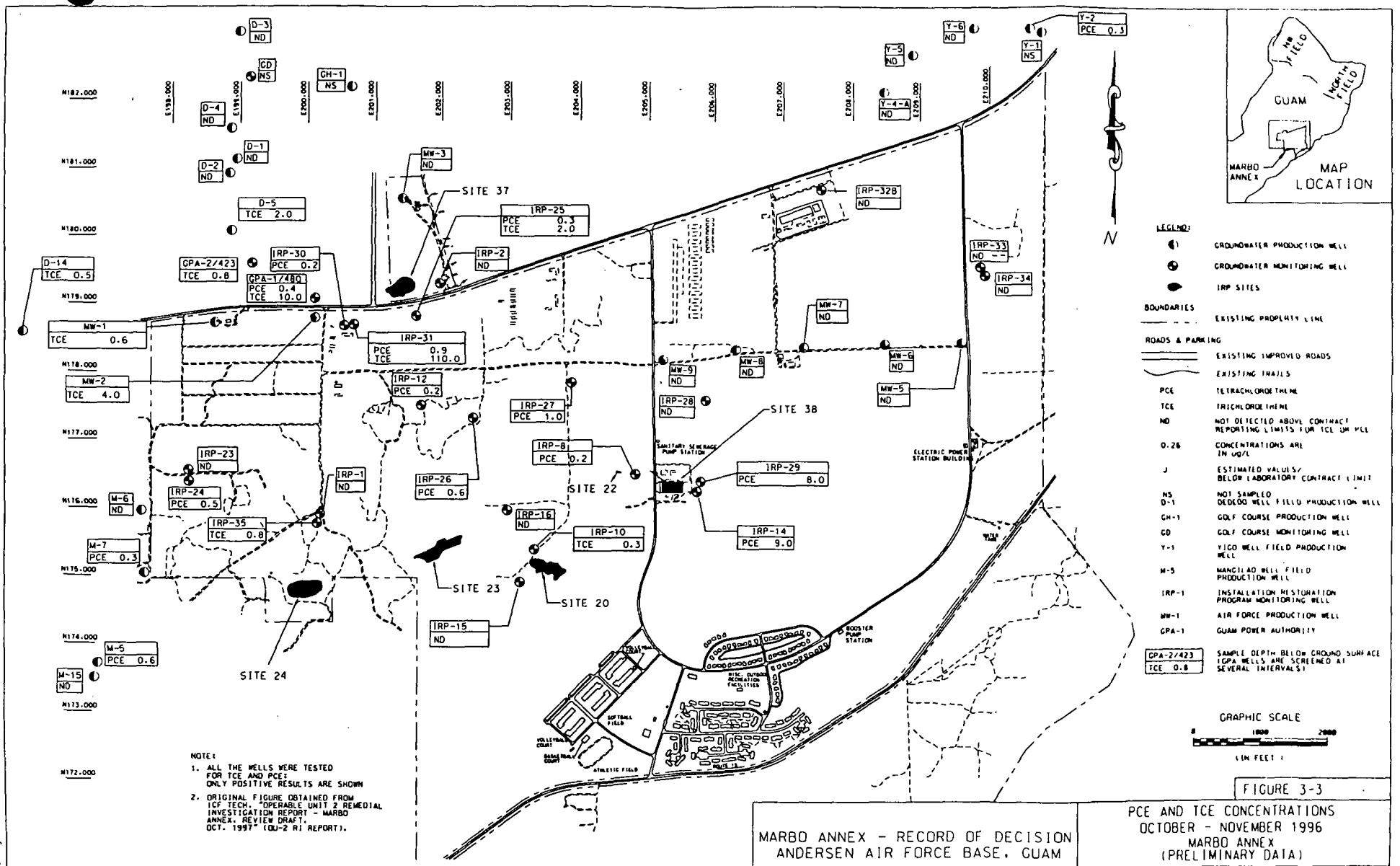


FIGURE 3-3

MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM

PCE AND TCE CONCENTRATIONS
OCTOBER - NOVEMBER 1996
MARBO ANNEX
(PRELIMINARY DATA)

DATE: 9/29/97 | SCALE: AS NOTED

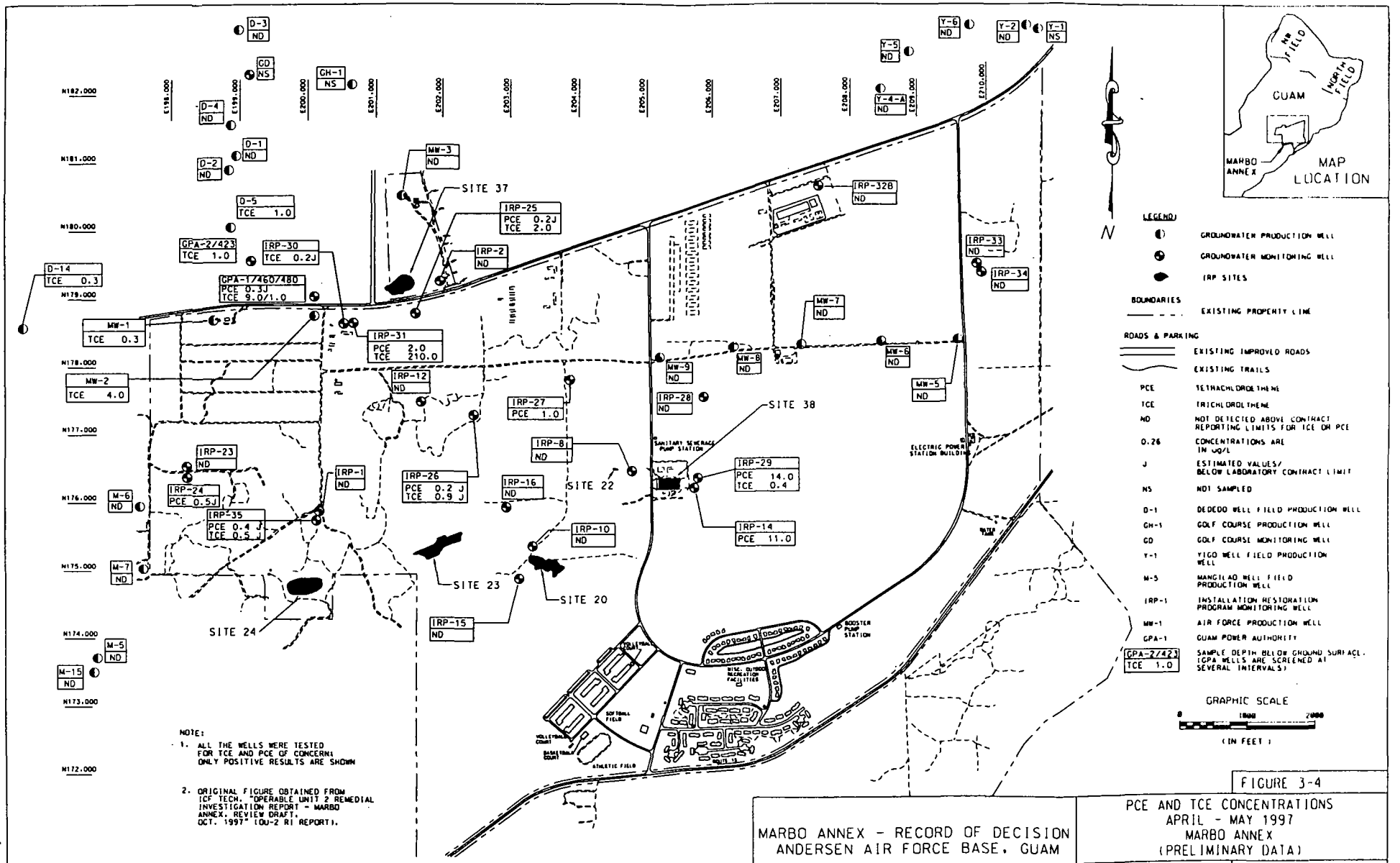
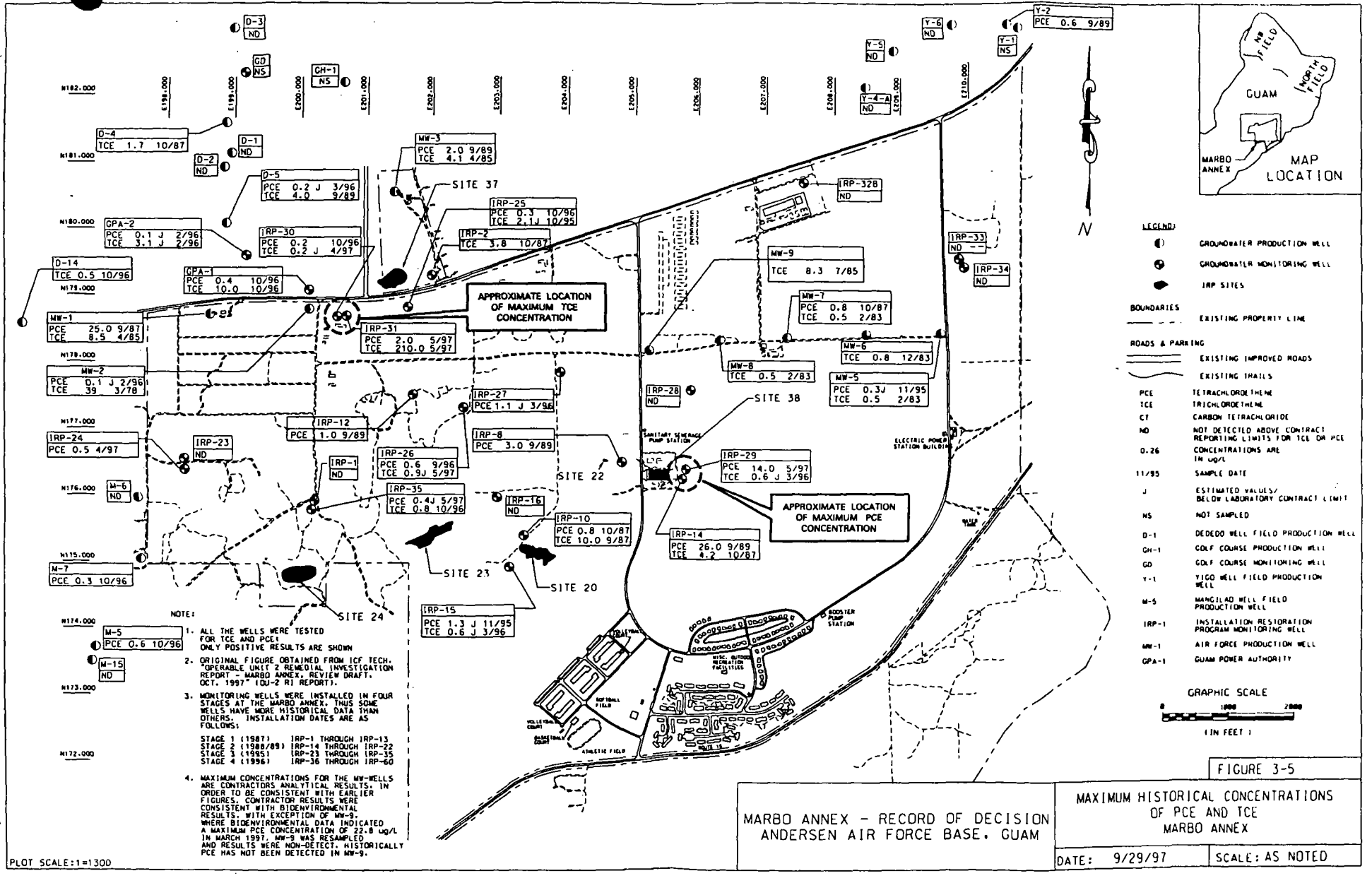


FIGURE 3-4

MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM

PCE AND TCE CONCENTRATIONS
APRIL - MAY 1997
MARBO ANNEX
(PRELIMINARY DATA)

DATE: 9/29/97 | SCALE: AS NOTED



NOTE:

1. ALL THE WELLS WERE TESTED FOR TCE AND PCE; ONLY POSITIVE RESULTS ARE SHOWN
2. ORIGINAL FIGURE OBTAINED FROM ICF TECH. "OPERABLE UNIT 2 REMEDIAL INVESTIGATION REPORT - MARBO ANNEX, REVIEW DRAFT, OCT. 1997" (OU-2 RI REPORT).
3. MONITORING WELLS WERE INSTALLED IN FOUR STAGES AT THE MARBO ANNEX. THUS SOME WELLS HAVE MORE HISTORICAL DATA THAN OTHERS. INSTALLATION DATES ARE AS FOLLOWS:

   STAGE 1 (1987) IRP-1 THROUGH IRP-13
   STAGE 2 (1988/89) IRP-14 THROUGH IRP-22
   STAGE 3 (1995) IRP-23 THROUGH IRP-35
   STAGE 4 (1996) IRP-36 THROUGH IRP-60

4. MAXIMUM CONCENTRATIONS FOR THE MW-WELLS ARE CONTRACTORS ANALYTICAL RESULTS. IN ORDER TO BE CONSISTENT WITH EARLIER FIGURES, CONTRACTOR RESULTS WERE CONSISTENT WITH BIOENVIRONMENTAL RESULTS. WITH EXCEPTION OF MW-9. WHERE BIOENVIRONMENTAL DATA INDICATED A MAXIMUM PCE CONCENTRATION OF 22.8 ug/L IN MARCH 1997. MW-9 WAS RESAMPLED AND RESULTS WERE NON-DETECT. HISTORICALLY PCE HAS NOT BEEN DETECTED IN MW-9.

PLOT SCALE:1=1300

directory file: doc/anderson/fig0_02-oct3.cgm

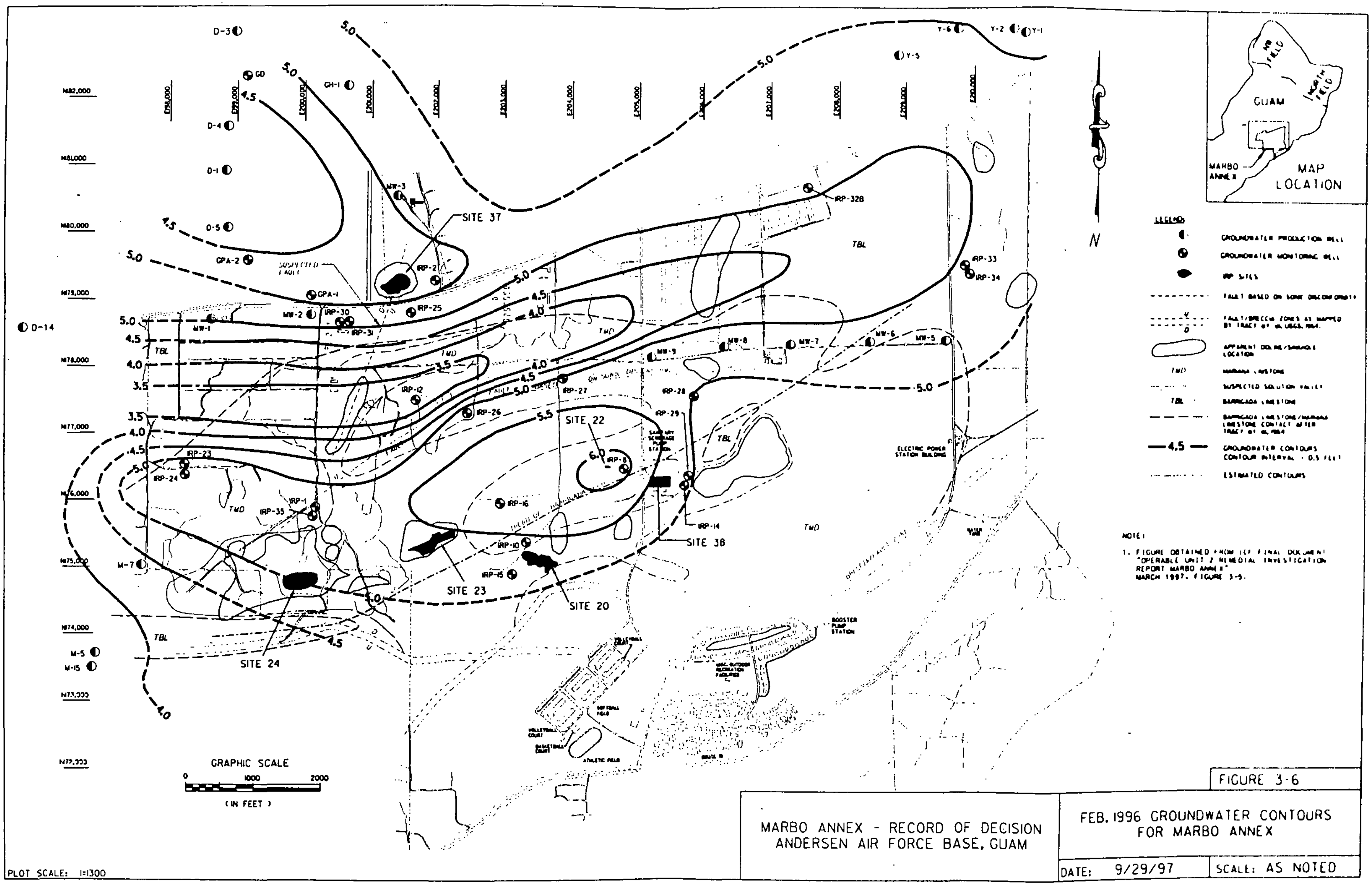
FIGURE 3-5

MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM

MAXIMUM HISTORICAL CONCENTRATIONS OF PCE AND TCE MARBO ANNEX

DATE: 9/29/97

SCALE: AS NOTED



MARBO ANNEX - RECORD OF DECISION
ANDERSEN AIR FORCE BASE, GUAM

FIGURE 3-6

FEB. 1996 GROUNDWATER CONTOURS FOR MARBO ANNEX

DATE: 9/29/97 SCALE: AS NOTED

TABLE 3-2

TCE CONCENTRATION RANGES AT MARBO ANNEX PRODUCTION WELLS AND MONITORING WELLS
(Page 1 of 2)

Well ID	Sampling Date Range[a]	Maximum Detection	Date of Max. Detection	Minimum Detection	Date of Min. Detection	April/May '97 Results
MW-1[b]	'78 to '97	8.5	4/85	0.3	5/97	0.3
MW-2[b]	'78 to '97	39	3/78	4.0	5/97	4.0
MW-3[b]	'78 to '97	4.1	4/85	ND[c]	5/97	ND
MW-5[b]	'78 to '97	0.5	2/83	ND	5/97	ND
MW-6[b]	'78 to '97	0.8	12/83	ND	5/97	ND
MW-7[b]	'78 to '97	0.5	2/83	ND	5/97	ND
MW-8[b]	'78 to '97	0.5	2/83	ND	5/97	ND
MW-9[b]	'78 to '97	8.3	7/85	ND	5/97	ND
D-1[b]	'78 to '97	ND	--	ND	--	ND
D-2[b]	10/96 to 4/97	ND	--	ND	--	ND
D-3[b]	10/96 to 4/97	ND	--	ND	--	ND
D-4[b]	'87 to '97	1.7	10/87	ND	4/97	ND
D-5[b]	'87 to '97	4.0	9/89	ND	10/87	1.0
D-14[b]	10/96 to 4/97	0.5	10/96	0.3	4/97	0.3
M-5[b]	10/96 to 4/97	ND	--	ND	--	ND
M-6[b]	'89,10/96-4/97	ND	--	ND	--	ND
M-7[b]	10/96 to 4/97	ND	--	ND	--	ND
M-15[b]	10/96 to 4/97	ND	--	ND	--	ND
Y-2[b]	'89 to '97	ND	--	ND	--	ND
Y-4A[b]	10/96 to 4/97	ND	--	ND	--	ND
Y-5[b]	10/96 to 4/97	ND	--	ND	--	ND
Y-6[b]	10/96 to 4/97	ND	--	ND	--	ND
IRP-1	'87 to '97	ND	--	ND	--	ND
IRP-2	'87 to '97	3.8	10/87	ND	4/97	ND
IRP-8	'87 to '97	ND	--	ND	--	ND
IRP-10	'87 to '97	10.0	9/87	ND	4/97	ND
IRP-12	'87 to '97	ND	--	ND	--	ND
IRP-14	'89 to '97	4.2	10/87	ND	4/97	ND
IRP-15	'89 to '97	0.6	3/96	ND	4/97	ND
IRP-16	'89 to '97	ND	--	ND	--	ND
IRP-23	10/95 to 4/97	ND	--	ND	--	ND
IRP-24(deep)[d]	10/95 to 4/97	ND	--	ND	--	ND
IRP-25	10/95 to 4/97	2.1	10/95	1.4	3/96	2.0
IRP-26	10/95 to 4/97	0.9	5/97	ND	10/96	0.9
IRP-27	10/95 to 4/97	ND	--	ND	--	ND
IRP-28	10/95 to 4/97	ND	--	ND	--	ND
IRP-29(deep)	10/95 to 4/97	0.6	3/96	ND	11/96	0.4
IRP-30	10/95 to 4/97	0.2	4/97	ND	10/96	0.2
IRP-31(deep)	10/95 to 4/97	210	5/97	110	11/96	210
IRP-32	10/95 to 4/97	ND	--	ND	--	ND

TABLE 3-2

TCE CONCENTRATION RANGES AT MARBO ANNEX PRODUCTION WELLS AND MONITORING WELLS

(Page 2 of 2)

Well ID	Sampling Date Range[a]	Maximum Detection	Date of Max. Detection	Minimum Detection	Date of Min. Detection	April/May '97 Results
IRP-33(deep)	10/95 to 4/97	ND	--	ND	--	ND
IRP-34	10/95 to 4/97	ND	--	ND	--	ND
IRP-35(deep)	10/95 to 4/97	0.8	10/96	0.5	5/97	0.5
GPA-1[e]	2/96 to 4/97	10.0	10/96	1.0	4/97	9.0
GPA-2[e]	2/96 to 4/97	3.1	2/96	0.8	10/96	1.0

Notes:

[a] Contractor results and BioEnvironmental results used for MW-wells.

[b] Production well - installed in the shallow portion of the freshwater lens.

[c] ND - Nondetectable concentrations.

[d] Deep monitoring well at the base of the freshwater lens (all other monitoring wells at top of lens).

[e] GPA-1 and GPA-2 are screened and sampled at variable depths. Max and min concentrations for entire well shown here. Highest concentration for April/May 1997 is shown in the last column.

TABLE 3-3

PCE CONCENTRATION RANGES AT MARBO ANNEX PRODUCTION WELLS AND MONITORING WELLS

(Page 1 of 2)

Well ID	Sampling Date Range[a]	Maximum Detection	Date of Max. Detection	Minimum Detection	Date of Min. Detection	April/May '97 Results
MW-1[b]	'87 to '97	25	9/87	ND[(2)]	5/97	ND
MW-2[b]	'87 to '97	0.1	2/96	ND	5/97	ND
MW-3[b]	'87 to '97	2.0	9/89	ND	5/97	ND
MW-5[b]	'87 to '97	0.3	11/95	ND	5/97	ND
MW-6[b]	'87 to '97	ND	--	ND	--	ND
MW-7[b]	'87 to '97	0.8	10/87	ND	5/97	ND
MW-8[b]	'87 to '97	ND	--	ND	--	ND
MW-9[b]	'87 to '97	22.8[d]/ND	3/97	ND	5/97	ND
D-1[b]	'87 to '97	ND	--	ND	--	ND
D-2[b]	10/96 to 4/97	ND	--	ND	--	ND
D-3[b]	10/96 to 4/97	ND	--	ND	--	ND
D-4[b]	'87 to '97	ND	--	ND	--	ND
D-5[b]	'87 to '97	0.2	3/96	ND	4/97	ND
D-14[b]	10/96 to 4/97	ND	--	ND	--	ND
M-5[b]	10/96 to 4/97	0.6	10/96	ND	4/97	ND
M-6[b]	'89, 10/96-4/97	ND	--	ND	--	ND
M-7[b]	10/96 to 4/97	0.3	10/96	ND	4/97	ND
M-15[b]	10/96 to 4/97	ND	--	ND	--	ND
Y-2[b]	'89 to '97	0.6	9/89	ND	4/97	ND
Y-4A[b]	10/96 to 4/97	ND	--	ND	--	ND
Y-5[b]	10/96 to 4/97	ND	--	ND	--	ND
Y-6[b]	10/96 to 4/97	ND	--	ND	--	ND
IRP-1	'87 to '97	ND	--	ND	--	ND
IRP-2	'87 to '97	ND	--	ND	--	ND
IRP-8	'87 to '97	3.0	9/89	ND	4/97	ND
IRP-10	'87 to '97	0.8	10/87	ND	4/97	ND
IRP-12	'87 to '97	1.0	9/89	ND	4/97	ND
IRP-14	'89to '97	26	9/89	ND	10/87	11
IRP-15	'89 to '97	1.3	11/95	ND	4/97	ND
IRP-16	'89 to '97	ND	--	ND	--	ND
IRP-23	10/95 to 4/97	ND	--	ND	--	ND
IRP-24(deep)[c]	10/95 to 4/97	0.5	4/97	ND	3/96	0.5
IRP-25	10/95 to 4/97	0.3	10/96	ND	3/96	0.2
IRP-26	10/95 to 4/97	0.6	9/96	ND	3/96	0.2
IRP-27	10/95 to 4/97	1.1	3/96	0.8	10/95	1.0
IRP-28	10/95 to 4/97	ND	--	ND	--	ND
IRP-29(deep)	10/95 to 4/97	14	5/97	5.7	3/96	14

TABLE 3-3

PCE CONCENTRATION RANGES AT MARBO ANNEX PRODUCTION WELLS AND MONITORING WELLS
(Page 2 of 2)

Well ID	Sampling Date Range[a]	Maximum Detection	Date of Max. Detection	Minimum Detection	Date of Min. Detection	April/May '97 Results
IRP-30	10/95 to 4/97	0.2	10/96	ND	4/97	ND
IRP-31(deep)	10/95 to 4/97	2.0	5/97	ND	10/95	2.0
IRP-32B	10/95 to 4/97	ND	--	ND	--	ND
IRP-33(deep)	10/95 to 4/97	ND	--	ND	--	ND
IRP-34	10/95 to 4/97	ND	--	ND	--	ND
IRP-35(deep)	10/95 to 4/97	0.4	5/97	ND	10/96	0.4
GPA-1[f]	2/96 to 4/97	0.4	10/96	ND	4/97	0.3
GPA-2[f]	2/96 to 4/97	0.1	2/96	ND	10/96	ND

Notes:

[a] Contractor results and BioEnvironmental results used for MW-wells.

[b] Production well - installed in the shallow portion of the freshwater lens.

[c] ND - Non Detectable concentrations.

[d] MW-9 was re-sampled. Subsequent result was ND. Historically, PCE has not been detected in MW-9.

[e] Deep monitoring well at the base of the freshwater lens (all other monitoring wells at top of lens).

[f] GPA-1 and GPA-2 are screened and sampled at variable depths. Max and min concentrations for entire well shown here. Highest concentration for April/May 1997 is shown in the last column.

CERCLA or the SDWA). Of the 29 wells, 21 of them are monitoring wells which were installed as part of the CERCLA process (IRP-wells) and eight of them are Air Force production wells (MW-wells). As discussed in Section 3.1, production wells from outside the MARBO Annex were also monitored with varying frequency, including: production wells from the adjacent Dededo production wellfield (D-wells), the nearby Yigo wellfield (Y-wells), the nearby Mangilao wellfield (M-wells), and two monitoring wells near the Guam Power Authority Dededo Power Plant (GPA-wells). Of the 21 IRP wells in the MARBO Annex, five of them are "deep" monitoring wells which were installed at the base of the freshwater lens (IRP-24, 29, 31, 33, and 35). The deep monitoring wells are generally screened approximately 90 to 100-feet below the production wells and shallow monitoring wells in order to monitor water quality near the freshwater/saltwater interface. The remaining IRP monitoring wells are installed in the upper portion of the freshwater lens, at approximately the same depth as production wells. The number of samples collected from each well varies considerably, based on when the well was installed, and/or when sampling commenced. For example, the Air Force production wells have samples dating back as far as 1978, whereas the more recently installed IRP-wells were installed in phases between 1987 and 1996, thereby having fewer overall samples.

Based on historical and recent sampling, TCE and PCE concentrations were detected above Federal MCLs at two locations inside the MARBO Annex. One location is southwest of Site 37 (directly south of the GPA Power Plant), where TCE was most recently detected at a maximum concentration of 210 µg/L in the deep monitoring well IRP-31. The other location is adjacent to the MARBO Laundry, where PCE was detected in two monitoring wells which are installed next to each other (monitoring wells IRP-14 and IRP-29), ranging from 11 to 14 µg/L. These locations are shown on Figure 3-5. The April/May 1997 sampling also indicated TCE exceeding MCLs in monitoring well GPA-1. A TCE source was not identified during either the OU 2 or OU 3 RIs. A definitive source for PCE near the MARBO Laundry was not identified during the OU 3 RI, but appears to be in the vicinity of the MARBO Laundry. The former dry cleaning facility at the MARBO Laundry may have discharged PCE to the base sanitary sewer via floor drains.

3.2.2 Fate and Transport of TCE and PCE

Complex structural features, lithologic features, and secondary porosity control groundwater flow and, therefore, complicate the migration of TCE and PCE. Groundwater flow within the MARBO Annex may be controlled by complex faulting near the center of the Annex, as described in the OU 2 RI report (ICF, 1997b). Groundwater flow to the southwest and northwest is additionally influenced by the numerous pumping wells which capture some of the groundwater flow. Groundwater flow at the south end of the MARBO Annex appears to be influenced by a groundwater mound just west of MARBO Laundry. To the south of this mound groundwater flow is southerly and may also be affected by a fault along the southern boundary of the MARBO Annex. It is uncertain if groundwater flows along this fault zone or passes through and continues south. Figure 3-6 shows groundwater elevation contours for February 1996. The contours are consistent with historical contours drawn at the MARBO Annex.

Groundwater flow from the MARBO Laundry area is believed to be primarily south and southwest based on groundwater contours and historically low-level concentrations (below MCLs) of PCE found in monitoring wells IRP-10 and IRP-15. Historical TCE and PCE concentrations can be seen on Figures 3-1 through 3-5. Low level detections of PCE were also detected in IRP-08, 26 and 27, which are to the north and west of IRP Site 38 (former MARBO laundry), possibly due to vadose zone dissolution channel flow and/or subsurface PCE residual outside the vicinity of the MARBO laundry.

Groundwater flow from the IRP-31 area appears to flow primarily into a groundwater trough where movement is westward. Some of the groundwater in this vicinity may also be influenced by flow gradients induced by on-site and off-site production wells. Due to the ubiquitous nature and persistence of chlorinated hydrocarbons, concentrations of TCE and PCE are detected at low levels at some of the monitoring wells at the MARBO Annex, generally at 1 µg/L or less. The highest concentrations detected in IRP-31 and IRP-14/29 may represent the locations where residual TCE/PCE is present as a continuing, but decreasing secondary source.

Cross-sectional information and a block diagram showing potential groundwater and contaminant migration pathways in the vadose zone and aquifer are included in the OU 2 RI report (ICF, 1997b). A description of the potential pathways and flow regime for groundwater and TCE/PCE was also discussed in the OU 2 RI and is summarized here for consistency. In the limestone karst environment, precipitation percolates rapidly into the soils and limestone bedrock. The upper portion of the epikarst zone limestone is capable of storing large volumes of water due to dissolution porosity that has developed with time. Dissolution decreases with depth, decreasing the storage capacity. Epikarst water is gradually released to the underlying vadose zone and to the aquifer as diffuse recharge. Discrete/concentrated runoff occurs only where there are enlarged joints, faults, brecciated zones, and surface depressions that concentrate runoff to a discrete subsurface inlet. The vertical migration of groundwater is altered due to interconnecting fractures, solution cavities, or lithologic changes. Vertical flow and flow along the hydraulic gradient occurs where vadose zone groundwater contacts the water table. The rate and direction of flow is further altered by encountering other preferential pathways. The flow regime in the vadose zone ranges from diffuse/slow flow, similar to a macro-porous media aquifer, to preferential/channeled fracture flow. Flow in the phreatic zone mimics the slow flow/diffuse flow (slow for a karst aquifer is approximately 20-30 ft/day) but is influenced by preferential pathways (ICF, 1997b).

Contaminant transformations can occur through degradation of the constituent, however this has been only minimally observed at the MARBO Annex, as evidenced by the lack of a significant occurrence of typical degradation by products such as cis-1,2-DCE and vinyl chloride. Groundwater velocities (20-36 ft/day) were derived from the dye trace investigation performed at the Main Base and Northwest Field Area (ICF, 1995). This estimate appears to be representative of the MARBO Annex based on the hydraulic gradient and lithology, and is consistent with other investigations indicating the age of the freshwater lens may be less than 5 years (Mink and Low, 1977). The OU 2 RI has assumed that if it takes 10 aquifer volumes to remediate the groundwater system, the aquifer will be cleansed naturally within 50 years, assuming no additional contamination is stored in the vadose zone. However, because of potential movement of contaminants from the vadose to the phreatic zone, contaminant persistence may continue for an unknown period of time, but should diminish, assuming the primary source is gone.

3.2.3 TCE and PCE Trends in Groundwater

In addition to the four sampling events from October 1995 to May 1997, some of the monitoring wells and production wells have been monitored for TCE and PCE prior to 1995. The range of sampling dates for each of these wells, as well as the historical maximum, minimum and most recent TCE and PCE concentrations, are shown on Tables 3-2 and 3-3. Based on some of the longer-term monitoring that has occurred at the MARBO Annex, it is possible to observe decreasing trends, or natural attenuation, of TCE and PCE. This is most evident in Air Force production wells MW-1 and MW-2, where TCE and/or PCE has been detected, and long term monitoring has occurred. Trends are expected to become more apparent in some of the recently installed monitoring wells, after additional sampling has been conducted.

As seen on Tables 3-2 and 3-3 the wells which have been monitored for 8 to 10 years or more show decreasing concentrations of TCE and PCE. The concentrations of TCE in MW-2 ranged from a high of 39 µg/L in 1978, to 4 µg/L in April 1997. TCE concentrations in MW-1 ranged from a high of 8.5 µg/L in 1985 to less than 0.3 µg/L in April 1997. Based on 8 years of sampling in the vicinity of the MARBO Laundry, PCE concentrations in monitoring well IRP-14 ranged from 26 µg/L in September 1989 to 11 µg/L in April 1996. Other IRP wells, although representing short-term data, also indicate a decrease in TCE and PCE concentrations. Though the newly installed monitoring wells have been monitored for only 1 to 2 years, the majority of these wells also indicate decreasing concentrations of TCE and PCE. Two of the monitoring wells, deep monitoring wells IRP-29 and IRP-31, indicate either steady, or slightly increasing concentrations of PCE and TCE, however this is over a period of only 2 years. Additional sampling of these wells, over a longer period of time, will provide sufficient information to indicate whether these wells will conform to the trends of the decreasing levels of TCE and PCE concentrations that have been observed in the other production and monitoring wells.

Historic data for the production wells and monitoring wells at the MARBO Annex has been compiled and graphed. Appendix A of the OU 2 FFS (EA and Montgomery Watson, 1997) illustrates TCE and PCE trends on graphs which plot TCE/PCE concentrations over time.

3.2.4 Potential Routes of Exposure

Human Health Risk. Exposure assumptions used for the human health risk assessment include potential ingestion and/or dermal exposure of groundwater, and inhalation of volatile constituents released from bathing and showering. Though production wells offer the only realistic exposure to groundwater, potential risk was also evaluated for monitoring wells. This scenario is considered unlikely, especially where some of the wells are installed at the base of the freshwater lens, in higher saline water.

Ecological Risk. An ecological risk assessment was performed in accordance with USEPA guidelines outlined in the OU 2 RI, presuming exposure to marine life through groundwater. There were no exposure pathways identified for terrestrial receptors.

3.3 SUMMARY OF SITE RISKS

3.3.1 Human Health Risk

The human health risk assessment for groundwater was also based on USEPA Region IX Preliminary Remediation Goal (PRG) guidance (USEPA, 1995). Groundwater analytical data obtained from each monitoring well and production well was compared to Region IX PRGs for tap water. Constituents with maximum concentrations exceeding the tap water PRGs were identified as constituents of concern (COCs). After separating out COCs as to their carcinogenic and non-carcinogenic potential, a cancer risk was calculated for COCs with carcinogenic potential, and an estimated hazard index was calculated for non-carcinogenic endpoints. Rather than calculate the Exposure Point Concentration for each compound, which was done for soil, the maximum concentration for each constituent was utilized. Individual constituent risk and HI were then summed to obtain total risk and HI for each production well and monitoring well.

As with soil, the USEPA considers a risk of less than $1x10^{-6}$ (one in one million) to be protective of human health, and uses this value as the point of departure. The USEPA has developed the

risk management range of $1x10^{-6}$ to $1x10^{-4}$ (one in ten thousand), as the target for managing cancer risk. The hazard index calculates potential non-cancer risks (e.g., skin lesions, decreased fertility, organ damage) that may be caused by exposure to a compound or group of compounds. For non cancer risk, the USEPA has recommended a hazard index equal to or less than one. A hazard index number below one indicates that non-cancer health effects are not expected.

For those production wells where COCs were detected, the health risk findings are shown in Table 3-4. The groundwater risk assessment utilized conservative assumptions, resulting in estimated risks that are likely higher than actual risks. As seen on Table 3-4, the potential risk for production wells where COCs were detected is within the risk management range of $1x10^{-6}$ to $1x10^{-4}$. Production wells MW-1, MW-2, and MW-3 are additionally treated with Air Stripping to remove low level concentrations of TCE and PCE, though MW-2 is the only production well where concentrations have recently exceeded MCLs[1]. Because risk is within an acceptable range for production wells at the MARBO Annex, groundwater quality goals at the MARBO Annex are primarily determined by federally allowable concentrations of TCE or PCE in the groundwater (i.e., MCLs). Remedial alternatives were evaluated to assess the feasibility of achieving concentrations of TCE and PCE in the aquifer to below the Federal MCL of 5 µg/L. Federal MCL's will also continue to be met at the Air Force supply wells presently being treated by Air Stripping. These public water supplies will be maintained as part of the Andersen AFB Long Term Monitoring Plan. Monitoring wells where COCs were detected are generally within EPA's risk management range of $1x10^{-6}$ to $1x10^{-4}$ and below a Hazard Index of 1, with the exception of IRP-31. Monitoring well IRP-31 exceeds the Hazard Index of 1, however this is a deep well with high chloride content and not meant for consumption. In addition, land use restrictions will be implemented to regulate the installation of new wells, and groundwater monitoring is included as a component to overall protection of human health and the environment.

[1] TCE concentrations have been below Federal MCLs since 1989 in MW-1, and have never exceeded MCLs in MW-3. PCE has never been detected above MCLs in either MW-1, 2, or 3. Groundwater from the off-site Tumon-Maui well is also treated by the same air strippers due to low levels of PCE detected in 1995.

TABLE 3-4

ESTIMATED HUMAN HEALTH RISK

Well ID[a]	Hazard Index	Potential Health Risk[b]	Estimated Current Risk
D-5[c]	0.044	$1x10^{-6}$	$1x10^{-6}$
MW-1[c,d]	0.033	$3x10^{-6}$	$<1x10^{-6}$
MW-2[c,d]	0.181	$4x10^{-6}$	$<1x10^{-6}$
MW-5[c]	0.004	$2x10^{-7}$	$2x10^{-7}$
GPA-1 - 420'[e,f]	0.075	$2x10^{-6}$	NA
GPA-1 - 480'[e,f]	0.182	$4x10^{-6}$	NA
GPA-2 - 423'[e,f]	0.085	$2x10^{-6}$	NA
GPA-2 - 483'[e,f]	0.063	$2x10^{-6}$	NA
IRP-14[e]	0.180	$1x10^{-5}$	NA
IRP-15[e]	0.130	$6x10^{-6}$	NA
IRP-25[e]	0.057	$1x10^{-6}$	NA
IRP-27[e]	0.018	$1x10^{-6}$	NA
IRP-29 (D)[e]	0.224	$9x10^{-6}$	NA
IRP-31 (D)[e]	4.34	$1x10^{-4}$	NA

[a] Production wells not shown did not detect TCE or PCE during the monitoring rounds utilized for the risk assessment.

[b] Based on risk assessment conducted in OU 2 RI.

[c] Production well.

[d] Production well presently treated with Air Stripping. The estimated current risk is less than $1x10^{-6}$ because the water from these wells is treated with the Air Stripper before distribution, removing the TCE and PCE.

[e] Monitoring well. Water from these wells is not consumed.

[f] GPA wells are sampled at different depths.

NA - Not Applicable. Monitoring well groundwater not consumed.

The OU2 RI Report (ICF, 1997) identified uncertainties in the human health risk assessment for groundwater. As previously described (Section 2.7), the presence of uncertainty is inherent in the risk assessment process. Potential sources of uncertainty in the OU2 RI human health risk assessment include, but are not limited to, the type of groundwater data evaluated, the EPCs used to estimate exposures, and the assumptions used in the exposure assessment. Groundwater data derived from IRP wells, production wells, and monitoring wells were used in the derivation of EPCs for groundwater constituents; some of these wells were screened at depths which are unlikely to serve as drinking water sources. Additionally, the maximum detected concentration was assumed as the EPC for each groundwater constituent. Furthermore, it was assumed that groundwater concentrations remain constant over a residential receptor's entire 30-year exposure duration; recent groundwater monitoring events indicate that natural attenuation of groundwater constituents is occurring. The conclusions of the OU2 RI Report (ICF, 1997) indicate that most sources of uncertainty in the human health risk assessment for groundwater erred on the protective side, and that the cancer risks and non-cancer HIs reported most likely represent overestimates. A more detailed, tabulated summary of the sources of uncertainty in the human health risk assessment for groundwater are included in Appendix B of this ROD.

Based on the results of the human health risk assessment for groundwater, actual or threatened releases of hazardous substances from the site, if not addressed by implementing the response actions selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

3.3.2 Ecological Risk

Based on a screening comparison to Ambient Water Quality Criteria that are protective of freshwater and saltwater organisms, there were no COCs identified, and therefore no ecological risk identified.

3.4 DESCRIPTION OF ALTERNATIVES

Three remedial alternatives were developed, as presented below.

3.4.1 No Action (Alternative G-1)

As required by the NCP, a no action alternative is developed and used as a baseline case for evaluating risk and for evaluating other alternatives. Under existing conditions at the MARBO Annex, human health risk is acceptable, falling within the USEPA cancer risk guidelines of 10^{-6} to 10^{-4}. No Action does not actively address TCE/PCE in the groundwater at the MARBO Annex. There are no institutional controls implemented, no considerations are made for protection of human health and the environment, and no process options are considered.

3.4.2 Natural Attenuation with Wellhead Treatment (Alternative G-2)

This alternative utilizes Natural Attenuation of TCE/PCE in the aquifer to achieve the remediation goal of decreasing TCE/PCE concentrations in the aquifer to concentrations below MCLs. Supplemental to this remedy are three institutional controls, including: 1) Land Use Restrictions (to monitor and restrict groundwater access in areas impacted by TCE/PCE); 2) Groundwater Monitoring (to monitor the decrease of TCE/PCE and confirm the stability of TCE/PCE plumes in the MARBO Annex); and 3) Existing Wellhead Treatment (to ensure public health risk is within acceptable range at existing Air Force production wells).

Natural Attenuation. As noted in the previous section, the decreasing trends of TCE and PCE in the groundwater at the MARBO Annex would be due to the physical processes of dispersion and dilution, which are largely dependent on the volume and rate of water traveling through the vadose zone and aquifer. The conditions at the MARBO Annex favor both of these factors. Average precipitation on the island of Guam is in the range of 100 inches per year. Over the 3.8 square mile area of the MARBO Annex, and assuming a 50% evapotranspiration rate, this equates to a recharge rate in the range of 3.3 billion gallons per year, or nine million gallons per

day. The combination of these high recharge rates in a transmissive limestone aquifer provide a supportive environment for accelerated physical natural attenuation of TCE and PCE. The natural attenuation would occur by "flushing" out any residual TCE/PCE remaining in the vadose zone and/or aquifer.

As illustrated earlier, there is good evidence that natural attenuation has occurred, and continues to occur, at the MARBO Annex. All of the production wells which have had either TCE or PCE detected in them show a decrease, and all of the monitoring wells which have had TCE or PCE detected in them, which have been monitored for greater than two years, also show a decrease. This is summarized on the table below:

TABLE 3-5

SUMMARY OF TCE/PCE CONCENTRATION CHANGES

	Number of Wells Indicating Changes in TCE/PCE Concentrations			
Well Type	**Decrease**	**Increase**	**No Change**	**Total Wells**
Production wells (8+ yrs of monitoring)	10	0	3 (All non detect)	13
IRP wells (>2 yrs of monitoring)	6	0	2 (All non detect)	8
IRP wells (2 yrs of monitoring)	1	3	9 (5 non detect)	13
GPA monitoring wells (1+ yrs of monitoring)	2	0	0	2
TOTAL:	19	3	14 (10 non detect)	36

Thus, all of the production wells, and all of the IRP monitoring wells that have been monitored for greater than 2 years, which have had concentrations of TCE or PCE detected in the past, indicate decreasing TCE and/or PCE concentrations. The monitoring wells which indicate an increase in TCE/PCE concentrations have been monitored for only 2 years. These monitoring wells are expected to follow the same decreasing trend as the other wells which have been monitored over a longer time period.

A degradation rate was estimated in order to estimate potential times for TCE and PCE to attenuate below MCLs. The range of degradation rates is considered roughly representative of how TCE and/or PCE reacts in the aquifer. The primary limitation to these estimates include the uncertainty of total TCE/PCE mass that may exist in the subsurface, which likely varies between the locations where wells presently exceed MCLs. Thus estimated cleanup times should take this in to consideration, with the understanding that actual cleanup times may exceed the high end of the range.

There are presently two locations (three monitoring wells) that exceed MCLs: IRP-31 exceeds the MCL for TCE, and IRP-14 and IRP-29 (located adjacent to each other) exceed the MCL for PCE. The estimated time to achieve the TCE MCL in IRP-31 may range from approximately 10 to 40 years. The estimated time to achieve the PCE MCL in IRP-14 may range from approximately 1 to 10 years. The estimated time to achieve the PCE MCL in IRP-29 may range from 2 to 10 years. Again, these are estimates which have limitations that should be considered.

Institutional Controls. As noted earlier, there are three institutional control mechanisms which are included with the Natural Attenuation remedy, as shown below:

- **Land Use Restrictions** involve placing restrictions on the property deeds pertaining to the installation of water supply wells on properties affected by PCE and TCE-impacted groundwater. The intent of land use restrictions is to reduce potential exposure to contaminants by legally restricting future groundwater development from those areas that are known to be impacted. The implementation mechanism for this component would be through GEPA's Wellhead Protection Program and Well Installation licensing and permitting. As part of the Wellhead Protection program, GEPA has developed a Groundwater Protection Zone Map which identifies those areas where surface activities above the resource or recharge zone have the ability to impact the water quality. The metes and bounds descriptions of the land are designated on this map along with other pertinent information (GEPA, 1993). GEPA reviews groundwater data from the Andersen AFB CERCLA process, and all well installation applications are reviewed by GEPA first prior to installation. Also, as part of the Wellhead Protection Program, well installation within 1,000 feet of an existing production well is prohibited. As GEPA has been involved with the development of this ROD, this would easily facilitate the necessary transfer of information from

Andersen AFB to GEPA, for implementation of the above-mentioned institutional controls.

- **Existing Wellhead Treatment** is in place for three of the production wells on the MARBO Annex (MW-1, MW-2 and MW-3) until TCE and/or PCE concentrations are consistently below MCLs. Two of these wells (MW-1 and MW-2) have slightly exceeded the MCL for TCE in the past. Groundwater at MW-1, 2 and 3 is presently routed through dual-packed, once-through, counter-current air stripping system with a hydraulic capacity of 725 gallons per minute (gpm). The endorsement and recommendation of continued wellhead treatment in these production wells would provide additional health risk benefit to those wells which exceed MCLs for TCE and/or PCE. Treatment status would be evaluated every two years in conjunction with the Andersen AFB Long-Term Groundwater Monitoring Plan;

- **Long-Term Groundwater Monitoring** involves the sampling and monitoring of the groundwater at the MARBO Annex through existing monitoring wells and production wells. The groundwater would be analyzed for TCE, PCE and other constituents which would be deemed pertinent for monitoring. Long-term monitoring is consistent with existing plans for monitoring under the IRP (EA Engineering and Montgomery Watson, 1995), and would monitor constituents in select IRP wells as well as production wells in and around the MARBO Annex. Monitoring would continue until TCE and PCE concentrations are consistently below MCLs.

3.4.3 Ex-Situ Groundwater Treatment (Alternative G-3)

This alternative was evaluated in order to assess the feasibility and level of effort that would be necessary to address groundwater restoration, where TCE/PCE exceeds MCLs in the aquifer. An effective evaluation of equipment, labor and cost is conducted here to assess the magnitude of effort necessary to address TCE and PCE in the groundwater. Should this alternative be evaluated for detailed consideration, a more comprehensive groundwater model would be necessary to optimize and calibrate the extraction system. Assuming these parameters could be met, and performance is measurable and accurate, the primary marginal benefit of this Alternative, when compared to the Natural Attenuation Alternative (Alternative G-2), would be that the TCE/PCE in the aquifer may be removed at a slightly accelerated rate.

The groundwater extraction scenario addresses TCE in the vicinity of IRP-31 and PCE in the vicinity of the former MARBO laundry. This alternative assumes two extraction wells at each location, pumping at 500 gpm each, with aboveground treatment via dual packed tower air strippers and discharge to separate, one acre percolation ponds at each location. A summary of the assumptions, conceptual layout and design is presented below; calculations are included in Appendix E of the OU 2 FFS.

- Assumes institutional controls similar to that for the Natural Attenuation alternative, including land use restrictions, long-term groundwater monitoring and continued wellhead treatment;

- Assumes two areas of concern within the MARBO Annex - the groundwater which is impacted by TCE in the vicinity of IRP-31, and the groundwater which is impacted by PCE in the vicinity of the former MARBO laundry;

- A radius of influence of 300 feet was estimated at each well (500 to 600 feet at each location), based on the site's physical information presented in the OU 2 RI. This is the equivalent of 1.5 mgd at each location, or 3 mgd combined. Each location is treated separately due to the distance (approximately 1 mile) between them;

- Assumes the upper end hydraulic conductivity value of 20,000 ft/day presented in the OU 2 RI (which equates to a transmissivity of 200,000 ft^2/day assuming 100-foot-thick fresh water lens);

- In order to maximize drawdown and account for potential pump downtime, two downhole pumps at each location are assumed to be pumping at 500 gpm each (four pumps total). A 100-HP pump in each of the four drawdown wells would be necessary in order to pump this volume of groundwater from the required depths;

- The pumps would discharge to a dual packed counter-current air stripping system at each location, similar to the one in place now;

- An average concentration of TCE of 80 µg/L was assumed at IRP-31, which is one half of the November 1995 and March 1996 concentrations. This value assumes dilution from the upper portion of the aquifer, where TCE was not detected, as well as groundwater flux toward the drawdown well from the outer edge of the TCE plume and surrounding volumes of the aquifer where TCE was not detected;

- An average concentration of 10 µg/L of total VOCs (PCE plus TCE) was assumed at the MARBO laundry area, where VOCs were detected throughout the length of the water column and in downgradient wells;

- Based on the average VOC concentrations at both locations, and the assumptions presented above, VOC off-gas is calculated to be approximately 0.06 tons/year for the IRP-31 area, and 0.02 tons/year for the MARBO laundry area. This is within the limits of 100 tons/year for a minor source, therefore off-gas treatment would not be necessary.

In summary, three alternatives were retained for evaluation, ranging from no-action to potential groundwater restoration. The No-Action alternative includes only the efforts and costs associated with a 5-year review, as required by CERCLA. Natural Attenuation is augmented with a combination of land use restrictions and groundwater monitoring, and continued commitment to wellhead treatment at the MARBO Annex. Ex-Situ Treatment utilizes artificial/technical means to potentially accelerate the attenuation of TCE/PCE in the aquifer, with continued commitment to wellhead treatment.

3.5 COMPARATIVE ANALYSIS OF ALTERNATIVES SUMMARY

The remedial alternatives developed were analyzed in detail using the nine evaluation criteria required by the NCP, as discussed in Section 2.8. These criteria are again shown below, and discussed relative to the groundwater remedial alternatives:

- Overall protection of human health and the environment
- Compliance with ARARs
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State/support agency acceptance
- Community acceptance

The resulting strengths and weaknesses of the alternatives were then weighed to identify the alternative providing the best balance among the nine criteria. Table 3-6 summarizes this comparison.

TABLE 3-6

COMPARISON OF GROUNDWATER ALTERNATIVES

Alternative	Compliance With ARARs	Protection of Human Health and the Environment[a]	Short-Term Effectiveness	Long-Term Effectiveness	Reduction of TMV[b]	Implementability	Cost x $1,000	Territorial Acceptance	Community Acceptance
No Action	Does not comply	Potential for future exposure	Not Effective	Not Effective	No reduction in TMV.	No Technical Limitations	$77	Not Acceptable	Not Acceptable
Natural Attenuation w/ Wellhead Treatment	Compliance achievable	Exposure potential reduced through natural attenuation of TCE and PCE	Effective	Effective	Some reduction in TMV.	Easy	$3,649	Acceptable	Acceptable
Ex-Situ Groundwater Treatment	Compliance achievable	Exposure potential reduced through engineered removal of TCE and PCE	Effective	Potentially effective, with likely adverse effect of saline intrusion	Some reduction in TMV.	Difficult	$18,447	Not Acceptable	Not Acceptable

Notes:

[a] Includes Short Term Effectiveness and Long Term Effectiveness and Permanence.

[b] TMV - Toxicity, Mobility and Volume of contaminant.

3.5.1 Overall Protection of Human Health and the Environment

The Natural Attenuation alternative addresses TCE and PCE in groundwater via the natural attenuation of these constituents, as shown through historical monitoring. Natural Attenuation would ensure overall protection of human health and the environment through natural remediation of the TCE and PCE in the aquifer. The risk pathway at the MARBO Annex is through drinking water, which is presently treated and monitored. Therefore the implementation of institutional controls augment the natural attenuation remedy in order to protect human health and the environment. Land use restrictions would be implemented to regulate the installation of new production wells. Wellhead treatment would continue at production wells MW-1, MW-2 and MW-3 until TCE and/or PCE concentrations consistently fall below MCLs (this will be evaluated every two years). As human health risk is presently within acceptable limits, the institutional controls would maintain and monitor this as a component to overall protection of human health and the environment. This alternative provides both short-term and long-term effectiveness.

The Ex-Situ Treatment alternative provides the same degree of overall protection of human health and the environment as the Natural Attenuation alternative, and the same set of institutional controls would be incorporated. It is possible that the TCE/PCE may be remediated at a slightly accelerated rate, however, the marginal benefit to the protection of human health and the environment would remain the same as the Natural Attenuation alternative. Overall protection of human health and the environment may be adversely affected by pumping at depth at high rates in the vicinity of IRP-31. The high pump rate required for this alternative may induce upconing of the deeper TCE, which would increase risk by introducing TCE in to the upper portion of the aquifer, where production wells draw from. For this reason, groundwater treatment (Alternative G-3) in lieu of natural attenuation (Alternative G-2) will likely not provide additional marginal benefit to protection of human health and the environment.

The No Action alternative is currently protective of human health and the environment, based on the fact that existing hypothetical cancer risk from production wells is within the EPA range of

10^{-6} to 10^{-4}. However, this alternative does not provide additional protection or assurance that potential exposure pathways may not exist in the future from either additional migration of TCE/PCE or the installation of new production wells.

3.5.2 Compliance with ARARs

The primary chemical-specific ARARs/TBCs which are considered applicable to the MARBO Annex are federal and local MCLs for TCE and PCE; Guam's Water Pollution Control Act (10 GCA 47); and Guam's Revised Water Quality Standards (GEPA, 1992). The primary action specific ARAR is Guam's Wellhead Protection Program (GEPA, 1993) and Guam's Water Resource and Development Operating Regulations (GEPA, 1990), which monitors the installation of extraction/pumping wells in or adjacent to wellfields, and reviews existing hydrologic and land-use data prior to approving the installation of new production wells. Prior to the installation of a new production well, applicants must submit the location of the proposed well to GEPA, who then reviews existing land use and hydrologic information in that area. Based on this information, GEPA has the authority to deny well installation in compromised portions of the aquifer. Andersen AFB will continue to work closely with GEPA in supplying all groundwater quality data collected as part of the IRP program, so that GEPA can maintain an adequate database for their Wellhead Protection Program.

Ex-situ treatment has been considered with the intent of meeting and/or accelerating the rate to achieve chemical-specific ARARs through engineered means. Whether artificial restoration would result in the achievement of ARARs in a more expeditious time frame is uncertain. By attempting to meet the ARAR for MCLs, other ARARs would likely be compromised, especially the drinking water standard for chlorides, due to chloride upconing and subsequent discharge to the percolation ponds. The pump rate required for a sufficient capture zone is high, and certain to result in significant upconing and degradation of the aquifer. Chloride upconing will affect the potable, upper portion of the freshwater lens, where production wells draw from. The upper limit chloride concentration for drinking water is 250 mg/L (GEPA, 1992). Chloride concentrations in the deeper monitoring wells are presently around 170 mg/L. Action and location specific

TABLE 3-7

CHEMICAL-SPECIFIC ARARs AND TBCs

Potential ARAR	Issues and Requirements	ARAR Status: Applicable	ARAR Status: Relevant and Appropriate	Applicability to FS Alternatives
FEDERAL REQUIREMENTS				
Drinking Water				
SDWA Maximum Contaminant Levels 40 CFR 141.11 to 141.16	Enforceable standards for public water systems.	Yes	Yes	G-1: Meets MCL at point of use but not aquifer. G-2: Meets MCL at point of use but not aquifer. G-3: Meets MCL at point of use and possibly aquifer.
Surface Water				
CWA, National Pollutant Discharge Elimination System (NPDES) 40 CFR 122 and 125	Regulates the discharge of water to surface water bodies.	Yes	Yes	G-1: Not applicable. G-2: Not applicable. G-3: Meets discharge requirements.
Other				
EPA Carcinogen Assessments Group Potency Factors	Most up-to-date information on cancer risks derived from EPA's Cancer Assessment Group (CAG).	Yes	Yes	Utilized for Risk assessment at MARBO complex.
NIOSH OSHA	Standards for worker exposure to specific chemical compounds.	Yes	Yes	G-1: Not applicable. G-2: Monitoring and sampling under existing HASP. G-3: Covered under future HASP and O&M manual.
GUAM REQUIREMENTS				
Drinking Water				
Guam SDWA, 10 GCA, Chapter 53	Establishes primary and secondary standards and MCL.	Yes	Yes	G-1: Meets MCL at point of use but not aquifer. G-2: Meets MCL at point of use but not aquifer. G-3: Meets MCL at point of use and possibly aquifer.
Groundwater				
Revised Guam Water Quality Standards, Adopted 7/18/87 and 1/2/92	Restricts, controls, and permits pollutant discharges, and defines water quality criteria.	Yes	Yes	G-1: Not applicable. G-2: Not applicable. G-3: Meets discharge requirements.
Water Pollution Control Act 10 GCA, Chapter 47	Determines ways and means of eliminating and/or preventing pollution to surface waters and groundwaters.	TBC	TBC	G-1: Does not address future conditions. G-2: Monitors long term conditions with institutional controls. G-3: Monitors long term conditions with marginal aquifer restoration.
Others				
Air Pollution Control Act, 10 GCA, Chapter 49	Establishes air quality criteria; sampling, testing, monitoring, record keeping requirements, source permitting system; and specific control requests.	Yes	Yes	G-1: Not applicable. G-2: Not applicable. G-3: VOC off-gas discharge within acceptable regulatory limits.

ARARs	Applicable and Relevant and Appropriate Requirements.	CWA	Clean Water Act.	MOU	Memorandum of Understanding.
RI/FS	Remedial Investigation/Feasibility Study.	POTW	Publicly Owned Treatment Works.	GEPA	Guam Environmental Protection Agency.
RCRA	Resource Conservation and Recovery Act.	MCL	Maximum Contaminant Level.	ROD	Record of Decision.
SDWA	Safe Drinking Water Act.	TBC	To Be Considered.	HASP	Health and Safety Plan.
EPA	Environmental Protection Agency.	GCA	Guam Code Annotated.		

TABLE 3-8

ACTION-SPECIFIC ARARs AND TBCs

Potential ARAR	Issues and Requirements	ARAR Status: Applicable	ARAR Status: Relevant and Appropriate	Applicability to FS Alternatives
FEDERAL REQUIREMENTS				
Safe Drinking Water Act (SDWA)				
40 CFR 144 Underground Injection Control Program	**Issues:** The control program restricts the underground injection of wastes and treated wastewater. **Requirements:** The underground injection of fluids must meet the established standards and procedures.	Yes	Yes	G-1: Not Applicable. G-2: Not Applicable. G-3: Infiltration pond meets established standards.
Occupational Safety and Health Act (OSHA)				
29 CFR 1910 120 Regulations for Workers Involved in Hazardous Waste Operations	**Issues:** These requirements must be implemented during hazardous waste operations. **Requirements:** The OSHA standards for hazardous waste operations include regulations for training, protective equipment, proper handling of wastes, monitoring of employee health, site information, and emergency procedures for workers at hazardous waste operations.	Yes	Potentially	G-1: Not applicable. G-2: Monitoring and sampling under existing HASP. G-3: Covered under future HASP and O&M manual. Employees may need Health and Safety 40-hour course and annually updated 8-hour refresher course.
29 CFR 1900 Standard for Worker Protection	**Issues:** These standards were developed to ensure a safe workplace. **Requirements:** In general, the OSHA standards have been promulgated to provide a workplace free of harm.	Yes	Yes	G-1: Not applicable. G-2: Monitoring and sampling under existing HASP. G-3: Covered under future HASP and O&M manual
Clean Air Act (CAA)				
CAA Section 109 and 40 CFR 50	**Issues:** Determine whether the air strippers would be considered a major source or minor source. **Requirements:** Permits and regulates air emissions if considered a major source.	Yes	Yes	G-1: Not applicable. G-2: Not applicable. G-3: Not considered a major source, therefore off gas treatment not required.
GUAM REQUIREMENTS				
Guam Wellhead Protection Program Adopted March 4, 1993 and Guam's Water Resource and Development Operating Regulations	Protects groundwater in wells/wellfields that supply drinking water. Regulates permitting of production and monitoring wells, and contractor licensing.	Yes	Yes	G-1: Not applicable. G-2: Not applicable. G-3: May affect installation of extraction well so close to existing production well field.
Water Resources Conservation Act 10 GCA, Chapter 48	Restricts development of groundwater through licensing and permit issuance for well drilling and operation, and sets construction standards.	Yes	Yes	G-1: Not applicable. G-2: Not applicable. G-3: Will address during permitting.
UIC Regulations	Restricts subsurface injection to prevent contamination and/or deterioration of groundwater resource.	Yes	Yes	G-1: Not applicable. G-2: Not applicable. G-3: Groundwater treated to within standards. Possible exceedance of chloride due to upconing.

ARARs	Applicable and Relevant and Appropriate Requirements.	POTW	Publicly Owned Treatment Works.
RI/FS	Remedial Investigation/Feasibility Study.	DOT	Department of Transportation.
EPA	Environmental Protection Agency.	NEPA	National Environmental Policy Act.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act.	TBC	To Be Considered.

TABLE 3-9

LOCATION-SPECIFIC ARARs AND TBCs

Potential ARAR	Issues and Requirements	ARAR Status: Applicable	ARAR Status: Relevant and Appropriate	Applicability to FS Alternatives
FEDERAL REQUIREMENTS				
Habitat/Wildlife				
Endangered Species Act of 1973 (16 USC 1531), 50 CFR 200, 402; Fish and Wildlife Coordination Act (16 USC 661); 33 CFR 320 to 330	Action to conserve endangered species or threatened species if action may be critical or threatens the habitat upon which species depend.	Yes	Yes	G-1: Not Applicable. G-2: Not Applicable. G-3: Will consult with Fish and Wildlife.
History				
National Historic Preservation Act (16 USC Section 469), 36 CFR 65, 40 CFR 6.301(b)	Action to recover and preserve artifacts if in an area where action may cause irreparable harm, loss, or destruction of significant artifacts.	Yes	Potentially	G-1: Not Applicable. G-2: Not Applicable. G-3: Will consult with Guam and National Register of Historic Places if necessary.
GUAM REQUIREMENTS				
5 GCA, Chapter 63	Lists endangered and threatened species; regulates wild game and fish.	Yes	Yes	G-1: Not Applicable. G-2: Not Applicable. G-3: Will consult with Fish and Wildlife.

ARARs Applicable or Relevant and Appropriate Requirements.
RI/FS Remedial Investigation/Feasibility Study.
CWA Clean Water Act.
F&W Fish and Wildlife Service.
GCA Guam Code Annotated.
TBC To Be Considered

ARARs would also factor into the location of the extraction wells, limiting the effectiveness of Ex-Situ treatment, as they are required to be no closer than 1,000 feet from an existing production well (GEPA, 1993). Remaining ARARs/TBCs and their applicability to each alternative are summarized in Tables 3-7 through 3-9.

The Natural Attenuation alternative meets chemical-specific ARARs (i.e., MCLs) through natural attenuation. There are no action or location-specific ARARs associated with this alternative. Long-term monitoring data indicates that groundwater restoration through natural attenuation has occurred and is still occurring. Assuming no additional contaminant sources, the remaining two areas exceeding MCLs (the vicinity of IRP-31 vicinity of the MARBO Laundry) would be expected to follow the same decreasing trend. As these areas have been monitored for only 2 years (except for IRP-14), this would be confirmed through longer-term monitoring.

Though MCLs are a Safe Drinking Water Act promulgation, which requires compliance at the point of use, CERCLA proposes the point of compliance in the aquifer. The No Action alternative does not provide a monitoring network or remedy to address ARARs.

3.5.3 Short-Term Effectiveness

All three alternatives are expected to be effective in the short term, as risk is currently within acceptable limits. The Ex-Situ alternative will be protective of workers during construction, as necessitated through the site work plan and health and safety plan. TCE/PCE concentrations are low enough that the public will not be endangered during the construction phase. Environmental impacts from construction of the air stripping system and percolation pond will be addressed through consultation with the USEPA, GEPA and the U.S. Fish and Wildlife Service. Impacts would include clearing approximately two acres for the infiltration ponds.

3.5.4 Long-Term Effectiveness and Permanence

The Natural Attenuation alternative provides long-term effectiveness through the natural attenuation of TCE and PCE. Long-term monitoring and continued wellhead treatment at production wells which are impacted by TCE/PCE will continue. Future groundwater development in impacted areas will be precluded through the establishment of land use restrictions and the wellhead protection regulations. This alternative is suited for long term effectiveness, as long term effectiveness of naturally decreasing TCE/PCE to below MCLs has been shown at other wells on the MARBO Annex which have exceeded MCLs in the past. The high precipitation flux through the vadose zone, and rapid groundwater movement through the aquifer effectively flushes potentially remaining TCE/PCE from the vadose zone and/or aquifer. This alternative does not have significant overhead and maintenance concerns beyond those which are required under the existing program to monitor existing wells.

The long-term effectiveness of the Ex-Situ treatment alternative is based on the efficacy of capture of the TCE/PCE impacted groundwater. Though all hydrogeologic environments have inherent complexities, limestone environments, such as that beneath the MARBO Annex, have added uncertainties due to potential secondary solution channeling and fracturing. Additionally, the depth to groundwater at the MARBO Annex is high, especially in monitoring wells IRP-31 and IRP-29, where TCE and PCE, respectively, presently exceed MCLs at the base of the freshwater lens. The effectiveness of a groundwater extraction system is largely dependent on the efficiency of groundwater and contaminant removal, and the ability to monitor removal. These complexities, and the uncertainty associated with the distribution of TCE/PCE in the groundwater, add an uncertainty to the monitoring and measurement of TCE/PCE removal. Where the Natural Attenuation alternative does not attempt artificial TCE or PCE removal from the aquifer, this level of design and monitoring is not a concern. The Ex-Situ treatment alternative is also disadvantageous due to high electricity requirements, an issue which the island of Guam is presently dealing with. The electricity demands must be considered and balanced with the marginal benefits of groundwater treatment and risks of saline upconing. Approximately 50 percent of the present worth cost is due to electricity. High groundwater

extraction rates would also tap in to the effective yield of the NGL as a drinking water source, thus reducing the overall available capacity of the lens. The marginal benefit for long-term effectiveness of Alternative G-3 would not exceed that of Alternative G-2.

The No Action alternative does not address PCE/TCE impacted groundwater and long-term effectiveness is not monitored.

3.5.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

The Ex-Situ Treatment alternative slightly reduces the toxicity, mobility and volume of contaminants through groundwater extraction and treatment. Presuming an effective capture zone, this alternative would provide additional marginal reduction of toxicity, mobility and volume of contaminants, over the Natural Attenuation alternative.

The Natural Attenuation alternative slightly reduces the mobility and volume of contaminants in the aquifer through continued pumping of production wells, and eliminates the toxicity through wellhead treatment, on an as-needed basis. Thus, the Natural Attenuation alternative provides some toxicity reduction through wellhead treatment. Due to the high dissolved oxygen concentrations, anaerobic reductive dehalogenization of TCE and PCE to potentially more toxic byproducts does not appear to be of concern at the site. This is evidenced primarily by a lack of degradation byproducts in the groundwater, supported by the high dissolved oxygen.

The No Action alternative does not reduce the toxicity, mobility or volume of contaminants.

3.5.6 Implementability

There are no implementability concerns for the No Action alternative since it is a no action alternative.

The Natural Attenuation alternative consists of very little implementation, as natural attenuation is occurring and will continue to occur. Groundwater monitoring procedures are already in place. Land use restrictions would need to be implemented and O&M considerations for the existing air strippers would need to be implemented for the long term. Equipment issues with this alternative may include the periodic replacement of monitoring well piston pumps and O&M associated with the existing air strippers.

The Ex-Situ Treatment alternative implements well installation, air stripping and percolation ponds, which all have predictable operating parameters, and are available for competitive bid to many vendors. Construction considerations include extraction well modeling and design, well and pump installation, construction of the air strippers and concrete pad, and excavation and construction of a percolation pond. O&M considerations include possible replacement of the extraction pumps, maintenance of the well screens, maintenance of the air strippers and packing material, maintenance of the distribution system to and from the air strippers, and maintenance of the percolation ponds.

Though groundwater extraction is a conventional and proven technology, the implementation of extraction in a deep aquifer with heterogeneous limestone conditions would be difficult. Air stripping is a proven technology and would be easily implemented. As noted earlier, electricity consumption and the impact on future sustainable yield from a sole source aquifer are also implementability concerns.

3.5.7 Cost

This assessment evaluates the costs of the remedial actions on the basis of present worth. Present worth analysis allows remedial actions to be compared on the basis of a single cost representing an amount that, if invested in the base year at an assumed interest (discount) rate and disbursed over the study period as needed, is sufficient to cover all costs associated with the remedial action over its planned life. This study assumes a 30-year duration and 5 percent discount rate. CERCLA guidance suggests a cost accuracy to within -30 percent to +50 percent. Detailed costs

are included in the OU 2 FFS (EA and Montgomery Watson, 1997) and, based on these assumptions, are presented below.

No Action. The estimated present worth cost for this alternative is $77,000. This includes a 5-year site review over the 30-year duration.

Natural Attenuation with Wellhead Treatment. The estimated present worth cost for this alternative is $3,649,000, including $12,000 in capital costs and $3,637,000 in present worth O&M costs.

Ex-Situ Treatment. The estimated present worth cost for this alternative is $18,447,000, including $2,488,000 in capital costs and $15,959,000 in present worth O&M costs.

3.5.8 State/Territory Acceptance

This assessment evaluates the technical and administrative issues and concerns that the State/Territory may have regarding each of the remedial actions. The USEPA and Guam EPA commented on the draft version of this document. As with the soil alternatives, the comments were both editorial and technical in nature, including the implementation mechanism for the selected groundwater alternative. After addressing comments and concerns, the USEPA and Guam EPA are in concurrence and agreement with the selected alternatives. Their comments, and Andersen AFB's responses to those comments, are included in Appendix C.

3.5.9 Community Acceptance

This assessment evaluates the issues of concerns of the public regarding the proposed alternatives. After release of the Proposed Plan, which presented Natural Attenuation with Wellhead Treatment as the preferred remedy, the community did not express objection during the public meeting or public comment period. Senator Brown noted concern pertaining to the

connection between soil contamination at Waste Pile 7 and the groundwater. Senator Brown's comments, and other public comments, are addressed in Section 4.0 of this document.

3.6 THE SELECTED REMEDY

Natural Attenuation with Wellhead Treatment provides the most effective balance of trade-offs with respect to the nine criteria, and is the preferred alternative. This alternative would protect human health and the environment, is effective in the short and long term, is easy to implement, and is cost effective. The remedy would continue until long term groundwater quality monitoring indicates that TCE and PCE concentrations are consistently below MCLs. Each five year review would: 1) determine if the remedy is still effective, and 2) determine if the remedy has achieved its goals, and thus can be discontinued. Additionally, the Andersen AFB Long Term Monitoring Plan will be reviewed every two years, which includes the groundwater monitoring wells at the MARBO Annex and immediate vicinity. A brief summary and comparative benefit of this alternative is presented below:

- TCE and PCE concentrations are decreasing and/or consistently at low levels, as seen where long term monitoring has occurred at Air Force production wells. TCE and PCE concentrations are also decreasing in the majority of monitoring wells within the MARBO Annex. Based on historical groundwater data collected from the MARBO Annex, TCE/PCE concentrations are expected to drop over time due to naturally high flushing rates in the vadose zone and aquifer, assuming there is no continuing source. Thus Natural Attenuation has shown to be an effective alternative in reducing TCE and PCE concentrations. Natural Attenuation would be monitored for effectiveness and applicability in recently installed monitoring wells to confirm decreasing concentrations.

- The higher concentrations of TCE and PCE are focused in two distinct areas within the MARBO Annex, and do not appear to be migrating. The two areas are southwest of Site 37 (primarily TCE in IRP-31), and area in the vicinity of the MARBO Laundry (primarily PCE in IRP-14 and 29). The low levels detected outside of these two areas are presently below MCLs, with the exception of GPA-1. Additionally, the TCE detected southwest of Site 37 is in the deep zone, which precludes the installation of production wells. Natural Attenuation would provide continued monitoring and confirmation of the stability of these two areas, as well as provide monitoring for overall decreasing trends.

- Existing risk at the MARBO Annex is presently within the USEPA's acceptable health risk range for the production wells. This would be maintained with continued wellhead treatment of MW-1, MW-2 and MW-3 (until TCE/PCE concentrations are consistently below MCLs), the incorporation of a long term monitoring plan, and by regulating the installation of potentially new production wells in areas that are impacted with TCE/PCE.

- Natural Attenuation with Wellhead Treatment has high implementability, and can be incorporated into existing Air Force plans to monitor groundwater over the short and long term.

- Natural Attenuation with Wellhead Treatment does not potentially compromise aquifer groundwater quality to conditions which may deteriorate due to excess pumping. The excessive high pump rates required for Ex-Situ Treatment would likely result in saline upconing.

- From a cost perspective, Natural Attenuation with Wellhead Treatment can be implemented at a minimal cost and provide maximum benefit, compared to the other two alternatives. Though more expensive than the No Action alternative, the benefits of Natural Attenuation with Wellhead Treatment outweigh its added cost. Conversely, the benefits associated with the additional costs for Ex-Situ Groundwater Treatment are marginal, uncertain and potentially detrimental to the aquifer.

3.7 STATUTORY DETERMINATIONS

The selected remedy satisfies the statutory requirements of Section 121 of CERCLA, as amended by SARA, in that the following mandates are attained:

- The selected remedy is protective of human health and the environment, will decrease site risks, and will not create short-term risk nor have cross-media consequences;

- The selected remedy complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action such as chemical-specific ARARs, chemical-specific clean-up standards, and action-specific ARARs;

- The selected remedy is cost-effective in its fulfillment of the nine CERCLA evaluation criteria through remediation of the contaminated groundwater in a reasonable period of time.

3.7.1 Protection of Human Health and the Environment

Through long-term monitoring, institutional control and continued wellhead treatment, the Natural Attenuation with Wellhead Treatment alternative will monitor and confirm that groundwater will not exceed drinking water standards. The Natural Attenuation alternative utilizes natural flushing of a highly transmissive aquifer to remove contaminated groundwater from the aquifer. The implementation of this remedy will not create any short-term risk nor any negative cross-media aspects.

3.7.2 Compliance with ARARs

All ARARs will be met by the selected remedy. The remedy will achieve compliance of chemical-specific clean-up standards. None of the anticipated actions for the Natural Attenuation alternative is expected to have a detrimental impact on endangered species.

3.7.3 Cost Effectiveness

The USEPA, the USAF, and the Territory of Guam believe that the selected remedy fulfills the nine criteria of the NCP and provides overall effectiveness in relation to its cost. The Natural Attenuation alternative has a total capital cost of approximately $12,000 and an approximate annual O&M present worth cost of $3,637,000. The total net present worth is $3,649,000 based on a 30-year estimate.

3.7.4 Utilization of Permanent Solution and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Possible

The selected remedy represents, to the reasonable extent possible, a cost-effective manner for remediating groundwater at the MARBO Annex. The remedy selected provides the best balance of long-term effectiveness and permanence, marginal reduction of TMV through wellhead treatment, short-term effectiveness, implementability and cost-effectiveness.

3.7.5 Preference for Treatment as a Principle Element

Contaminants of concern in the groundwater will be removed through natural attenuation of the aquifer. Remediation of the groundwater will occur naturally, without the use of a treatment technology. The balance of natural means versus artificial means favors utilizing natural means to remediate the aquifer when compared to the overall effectiveness, cost, and implementation of an engineered alternative.

3.8 DOCUMENTATION OF SIGNIFICANT CHANGES

The Focused FS and Proposed Plan for the MARBO Annex based the overall cost of the Natural Attenuation remedy on a long term monitoring plan of 40 wells (including some production wells). As noted in the Proposed Plan and Focused FS, the actual number of wells to be monitored will be re-evaluated every two years, as longer term data becomes available. This does not impact the remedy, but will impact (decrease) cost in the long term. Per the October 22, 1997 Remedial Project Manager's (RPM) meeting, Andersen AFB and the USEPA and GEPA agreed to an initial reduction of wells for monitoring at the MARBO Annex, for a total of 26 wells. This decision was made after two years of sampling at the MARBO Annex, where the reduction of wells was based on either consistent non-detectable concentrations of TCE and PCE, or concentrations consistently below MCLs. A summary of this data is included in the OU 2 FFS (EA and Montgomery Watson, 1997) and the Andersen AFB Groundwater Summary Report (EA and Montgomery Watson, 1997). The reduction in the number of wells would reduce the estimated 30-year present worth cost of this remedy to approximately $2,364,000[2]. Re-evaluation of the long term monitoring program at the MARBO Annex will occur every two years in accordance with the Final Groundwater Monitoring Plan (EA and Montgomery Watson, 1995).

[2] This includes the following monitoring and production wells for monitoring:
Production wells D-2, D-5, D-14, M-6, and M-7.
Monitoring wells IRP-1, 2, 8, 10, 12, 14, 15, 16, 23, 24, 25, 26, 27, 29, 30, 31, 33, 34, and 35 and GPA-1 and GPA-2.

4.0 RESPONSIVENESS SUMMARY

4.1 OVERVIEW

The public comment period for the Proposed Plan began on October 10, 1997 and ended on November 10, 1997. A public notice summarizing the Proposed Plan, and announcing the public comment period and public meeting was printed in the Pacific Daily News from October 8 through October 10.

At the public meeting, which was held on October 24, 1997, questions and comments were received from the audience related to the Proposed Plan. A transcript of the public meeting minutes has been included in the Administrative Record. Judging from the comments received, the community accepts the USAF's preferred remedial alternatives for addressing soil and groundwater contamination at the MARBO Annex. There were no written comments received during the 30-day public review period.

4.2 BACKGROUND ON COMMUNITY INVOLVEMENT

In an effort to involve the community, Anderson AFB established the Restoration Advisory Board (RAB), which includes representatives from the local community. The RAB replaced the Technical Review Committee, which consisted primarily of elected officials and Government of Guam Agency Representatives. Since its establishment in 1995 the RAB has regularly held quarterly meetings, which are open to the public. The RAB serves as a focal point for environmental exchange between Andersen AFB and the local community. In addition to the announcement of the Proposed Plan in the *Pacific Daily News* from October 8 through October 10, 1997, a press release was also distributed to radio and television companies.

Andersen AFB presented a summary of proposed remedial alternatives and solicited comments on the Proposed Plan at a public meeting on Friday, October 24, 1997 at the Guam Hilton.

Representatives from Andersen AFB, GEPA, and USEPA were present at the meeting to answer questions; a transcript of this meeting is available for the public in the administrative record.

4.3 SUMMARY OF COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD

Comments received during the Andersen AFB MARBO Annex public comment period on the final OU 2 and OU 3 FS, and the Proposed Plan are summarized below. The comment period was held from October 10, 1997 to November 10, 1997. The comments are presented in the order in which they were received.

Public Meeting Comments Summary

Senator Joanne Brown, member of the 24th Guam Legislature and co-chair of the AAFB Restoration Advisory Board (RAB): Senator Brown followed up on the comments she made at last week's RAB meeting. Her comment addressed the issue of how sites are treated, particularly Waste Pile 7. The risk assessment process evaluates sites by assessing the threat they pose to contaminating groundwater (drinking water). However, from a public policy-making perspective, the condition of the land when it is returned to the people of Guam is also a concern. Public policy-makers must ensure that the lands that are returned to the people of Guam are useable. Risk assessments do not take into account this concern. Other environmental policy issues, such as the how useable the land is when it is returned, should also be considered. Southern High School is an example of how past waste disposal interfered with the construction of the school. In the future, the technology may be available to clean up these sites. On going monitoring is also critical particularly with regard to constituents that may be contained in Waste Pile 7.

The Proposed Plan recommends that AAFB will leave the constituents in place at this two-acre property and return it to the people of Guam with restrictions on how the property can be used. Our ultimate objective is to see that as much of this property is as usable as possible in the future. This will be a concern with other sites as we move along in the process. Funding and

environmental cleanup decisions are looked at in terms of the threat posed to groundwater, but this should not be the only issue. Returning this property to the people of Guam in its original condition so that it can be used by the people of Guam is an important issue. Future land use considerations should be part of the decision-making process in addition to the threats posed to groundwater.

The metallic waste in Waste Pile 7 may not pose a major threat to the groundwater, but it will limit the use of this property in the future. It needs to be made very clear to the people of Guam that this property is going to have restrictions on future development. The average person on the street is not going to understand the concept of risk assessment and setting priorities on the basis of the risk assessment. What they will understand is whether or not the land is usable. The current proposal is going to limit their use of this property in the future. Under the current process, we are going to take a map and begin to draw little circles around areas that are going to have restrictions even if the land is returned to the people of Guam. This is a legitimate concern because ultimately the desire is to see that when the property is returned it is returned in a usable form. Otherwise we are going to have chunks of Guam that are not usable. This will be the reality if we continue to deal with the concept of only dealing with these sites in terms of their threat to groundwater. If we continue to leave constituents in the ground, then we will have more and more unusable property in the future.

AAFB Response: Dr. Mark Rodriguez of the Waste Policy Institute reported that the MARBO Proposed Plan used Preliminary Remedial Goals (PRGs) to assess the risks to human and health posed by the sites. He said that PRGs are concentrations that are protective of human health. He stated that the key point to understand is that by using a soil cover at Waste Pile 7, the exposure pathway is limited. The soil cover will prevent health problems from occurring. As far as future use of the property, he noted that deed restrictions will determine how the land will be used.

Additionally, Site 20 lies within an abandoned quarry, with an average depth to the base of the fill of 10.8 feet bgs, and as such it has limited future land use regardless of whether the waste pile was removed. The restrictions on Waste Pile 7 would limit the use of the property to activities which are non-intrusive in nature, and would be included in the deed drilling transfer. Intrusive

activities would open an exposure pathway and defeat the purpose of the soil cover. Some ideas of non-intrusive activities use may include a maintenance yard or storage area.

Fred Castro, AAFB RAB member: Has the Proposed Plan been reviewed by the regulators? Were there any outstanding issues?

AAFB Response: The Proposed Plan was reviewed by Guam Environmental Protection Agency and U.S. Environmental Protection Agency. Mark Ripperda from the U.S. Environmental Protection Agency said that he approved the Proposed Plan and that he had no outstanding issues. Victor Wuerch from the Guam Environmental Protection Agency said that he also approved the Plan. He noted that his major concern is to protect groundwater and that the Proposed Plan recommends long-term groundwater monitoring at MARBO Annex.

Fred Castro: What is the estimated cost for the cleanup and monitoring and what is the status of the funding? If there is a change in the constituents in the groundwater, how will the necessary money be obtained to cleanup the site? On average, how much funding (total capital outlay) is available each year.

AAFB Response: The estimated costs are in the Proposed Plan. AAFB has FY97 funds to cleanup the sites at MARBO based on the recommended alternatives in the Proposed Plan. AAFB expects to receive funds for continued groundwater monitoring. AAFB will have to request for funds for monitoring on a yearly basis. If there are major changes to the Proposed Plan, AAFB will have to submit other requests for funds. AAFB averages approximately $10 million per year for the IRP.

Ernie Wusstig, Board of Directors for the Guam Soil and Water Conservation District: What kind of damage has occurred to our aquifer from all of the pollution, that is all of the chemical waste from military activities. I was born and raised in Yigo and I have seen all kinds of military activities. Now, thirty years later, why has it taken so long to address these issues? What has the military done to damage our aquifer?

AAFB Response: Extensive groundwater studies have been conducted in this area. AAFB has installed monitoring wells and it samples these wells and the production wells. The chemicals that have been detected are volatile organic compounds including tetrachloroethylene (PCE) and trichloroethylene (TCE). These chemicals are addressed in the Proposed Plan. The Proposed Plan recommends wellhead treatment and natural attenuation to remove the PCE and TCE from the aquifer.

There are two areas of concern in the groundwater underlying the MARBO Annex, where concentrations of TCE and/or PCE exceed Federal allowable levels. One is beneath the former MARBO Laundry, where PCE slightly exceeds Federal levels, and the other is across from the Yigo Power Plant, where TCE exceeds Federal levels. Though the PCE underlying the MARBO Laundry is likely a result of military activities, it is unclear where the source of the TCE originated. After approximately 10 years of monitoring these areas, the TCE and PCE do not appear to be migrating. Thus, the overall impact on the aquifer is isolated to two small areas representing a very small portion of the groundwater underlying the MARBO Annex.

On a broader, national level, impacts to soil and groundwater from industrial activities were not known to be an issue until the early 1970s. The military has been consistent and pro-active with investigative and remedial activities occurring nationally. Should there have been a situation where an imminent health risk existed, immediate measures would have been taken.

Ernie Wusstig: Where was all of the used oil from the vehicles dumped over the years? Do you have any data that shows where the used oil was disposed? Is there any evidence of contamination at MARBO?

AAFB response: AAFB analyzes its samples for petroleum products, but it has not detected any petroleum products in the groundwater samples. It also has not found large quantities of petroleum products in the six Installation Restoration Program (IRP) sites.

Rudy Wusstig: Where has the wastewater from MARBO Annex been going for the past 30 years? We used to farm in the MARBO cave area and we used to see wastewater disposed there.

AAFB Response: The sewage outfall was part of another investigation. It is in the area designated as excess land in Public Law 103-339. AAFB collected samples in the sewage outfall area near MARBO cave and nothing over acceptable levels was detected.

Rudy Wusstig: There are a lot of people from Guam that are so heavy in lead poisoning. My mother had high levels of lead in her blood. Where is this lead coming from and is it coming from our water?

AAFB Response: Island-wide, Guam has noticeable background concentration levels of lead associated with the groundwater. AAFB has not been able to attribute the lead to any of the IRP sites at MARBO. These levels are also found in places around the island far away from Air Force property such as central Guam, Pago Pago, and Ordot. These concentration levels are not above the levels that may pose a risk to human health. It is hard to determine if the prevalence of lead poisoning in many of the people is attributable to water or to another source. Another source of lead could be attributed to the lead solder in copper pipes in older water distribution systems. It could also come from lead-based paint.

Rudy Wusstig: There are also high incidents of degenerative diseases on Guam like diabetes in Guam. There is three percent hereditary diabetes nation wide, but I saw a study that said Guam had a 33 percent rate of diabetes.

AAFB Response: Not a question, but a statement. No response necessary.

Rudy Wusstig: Why did the Air Force have the sewage outfall at the MARBO cave for years and years?

AAFB Response: It was the acceptable practice at that time.

Rudy Wusstig: Why was this an acceptable practice in Guam when at the time it was not an acceptable practice in California or other parts of the mainland?

AAFB Response: This practice was acceptable at that time, both on Guam and many places on the mainland.

Jesus Torres: Nice program. What are the schedule dates? Will these studies go on forever? Have you any idea when some of these studies will be completed? Please advise.

AAFB response: The MARBO Annex sites are expected to be closed out by December 1998. The studies for the MARBO Annex Operable Unit are completed.

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APPENDIX A

REGION IX PRELIMINARY REMEDIATION GOALS (PRGs) SECOND HALF 1995

September 1, 1995

Subject: Region IX Preliminary Remediation Goals (PRGs) Second Half 1995

From: Stanford J. Smucker, Ph.D.
Regional Toxicologist (H-9-3)
Technical Support Section

To: PRG Table Mailing List

Please find the update to the Region IX PRG table. The table has been revised to reflect the most current EPA toxicological and risk assessment information. Updates to EPA toxicity values were obtained from IRIS through July 1995 and HEAST through November 1994.

Although Region 9 risk-based PRGs are "evergreen" and will change as new methodologies and parameters are developed, they have matured and are changing less than in the past. Meanwhile, the mailing list has increased exponentially and updating and distributing the table by mail has become a considerable burden. Upon reflection, we've decided to change from a semi-annual to annual distribution beginning in 1996. We think this change will allow us to keep publishing the PRG table, while having little effect on the table's usefulness.

If you are not currently on the PRG mailing list, but would like to be, please make the request through EPA's project manager working on your site. Or, for faster service, simply download the file (PRG2ND95.ZIP) from California Regional Water Board's BBS [(510) 286-0404]. Also, in the not-too-distant future, we anticipate that the PRG table will be available via internet access. To determine whether the file is available through this delivery system, direct gopher client to "gopher.epa.gov" and select the following menus: EPA Offices and Regions; Region 9; Superfund Program.

Before relying heavily on any number in the table, it is recommended that the user verify the numbers with a toxicologist or Regional risk assessor because the toxicity / exposure information in the table may contain errors or default assumptions that need to be refined based on further evaluation. If you find an error please send me a note via fax at (415) 744-1916.

This version of the table contains new toxicity values for arsenic, benzene, 1-chloro-1,1-difluoroethane (HCFC-142b), cobalt, danitol, hydrogen chloride, hydrogen sulfide, methyl mercury, and phosphine. The updated values are indicated in boldface print in the table.

DISCLAIMER

Preliminary remediation goals (PRGs) focus on common exposure pathways and may not consider all exposure pathways encountered at CERCLA / RCRA sites (Exhibit 1-1). PRGs do not consider impact to groundwater or address ecological concerns. PRGs are specifically not intended as a (1) stand-alone decision-making tool, (2) as a substitute for EPA guidance for preparing baseline risk assessments, or (3) a rule to determine if a waste is hazardous under RCRA.

The guidance set out in this document is not final Agency action. It is not intended, nor can it be relied upon to create any rights enforceable by any party in litigation with the United States. EPA officials may decide to follow the guidance provided herein, or act at variance with the guidance, based on an analysis of specific circumstances. The Agency also reserves the right to change this guidance at any time without public notice.

1.0 INTRODUCTION

The Region IX PRG table combines current EPA toxicity values with "standard" exposure factors to estimate concentrations in environmental media (soil, air, and water) that are protective of humans, including sensitive groups, over a lifetime. Concentrations above these levels would not automatically designate a site as "dirty" or trigger a response action. However, exceeding a PRG suggests that further evaluation of the potential risks that may be posed by site contaminants is appropriate. Further evaluation may include additional sampling, consideration of ambient levels in the environment, or a reassessment of the assumptions contained in these screening-level estimates (e.g. appropriateness of route-to-route extrapolations).

PRG concentrations presented in the table can be used to screen pollutants in environmental media, trigger further investigation, and provide an initial cleanup goal if applicable. When considering PRGs as preliminary goals, residential concentrations should be used for maximum beneficial uses of a property. Industrial concentrations are included in the table as an alternative cleanup goal for soils, but it is not recommended that industrial concentrations be used for screening sites.

Before applying PRGs as screening tools or initial goals, the user of the table should consider whether the exposure pathways and exposure scenarios at the site are fully accounted for in the PRG calculation. Region IX PRG concentrations are based on exposure pathways for which generally accepted methods, models, and assumptions have been developed (i.e. ingestion, dermal contact, and inhalation) for specific land-use conditions and do not consider impact to groundwater or ecological receptors (see Developing a Conceptual Site Model below).

EXHIBIT 1-1
TYPICAL EXPOSURE PATHWAYS BY MEDIUM
FOR RESIDENTIAL AND INDUSTRIAL LAND USES[a]

EXPOSURE PATHWAYS, ASSUMING:		
MEDIUM	RESIDENTIAL LAND USE	INDUSTRIAL LAND USE
Ground Water	***Ingestion from drinking***	Ingestion from drinking
	Inhalation of volatiles	Inhalation of volatiles
	Dermal absorption from bathing	Dermal absorption
Surface Water	***Ingestion from drinking***	Ingestion from drinking
	Inhalation of volatiles	Inhalation of volatiles
	Dermal absorption from bathing	Dermal absorption
	Ingestion during swimming	
	Ingestion of contaminated fish	
Soil	***Ingestion***	***Ingestion***
	Inhalation of particulates	***Inhalation of particulates***
	Inhalation of volatiles	***Inhalation of volatiles***
	Exposure to indoor air from soil gas	Exposure to indoor air from soil gas
	Exposure to ground water contaminated by soil leachate	Exposure to ground water contaminated by soil leachate
	Ingestion via plant, meat, or dairy products	Inhalation of particulates from trucks and heavy equipment
	Dermal absorption	***Dermal absorption***

Footnote:
[a]Exposure pathways considered in the PRG calculations are indicated in boldface italics.

2.0 READING THE PRG TABLE

2.1 General Considerations:

With the exceptions described below, PRGs are risk-based concentrations that correspond to either a one-in-one million (10^{-6}) cancer risk or a noncarcinogenic hazard quotient of one, whichever is lower. In most cases, where a substance causes both cancer and noncancer or systemic effects, the 10^{-6} cancer risk will result in a more stringent criteria and consequently this value is presented in the table. PRG concentrations based on cancer risk are indicated by "ca". PRG concentrations based on noncarcinogenic health threats are indicated by "nc".

If the risk-based concentrations are to be used to screen sites, it is recommended that both cancer and noncancer-based PRGs be obtained even though the printed list will contain only the more conservative of the two values. To obtain additional values (e.g. noncancer PRGs for a carcinogenic substance), the user has two options. The simplest option is to obtain the complete set of PRGs by downloading the file (PRG2ND95.ZIP) from California Regional Water Board's Bulletin Board System at [(510)286-0404)]. Or, if no modem is available, one could use the equations provided below to calculate additional PRGs.

It has come to my attention that some users have been multiplying the cancer PRG concentrations by 10 or 100 to set "action levels" for triggering remediation or to set less stringent cleanup levels for a specific site after considering non-risk-based factors such as (ambient levels, detection limits, or technological feasibility). This practice recognizes that there may be a range of values that may be "acceptable" for carcinogenic risk (EPA's cancer risk range is from 10^{-6} to 10^{-4}). However, this practice could lead one to overlook serious noncancer health threats and it is strongly recommended that the user consult with a toxicologist or Regional risk assesssor before doing this. For carcinogens, I have indicated by asterisk ("ca**") in the PRG table where the noncancer PRGs would be exceeded if the cancer value that is listed is multiplied by 100. Two stars ("ca***") indicate that the noncancer values would be exceeded if the cancer PRG were multiplied by 10. There is no range of "acceptable" noncarcinogenic "risk" so that under no circumstances should noncancer PRGs be multiplied by 10 or 100, when setting final cleanup criteria.

In addition to federal PRGs, the PRG table also includes California EPA PRGs ("CAL-Modified PRGs") for specific chemicals where CAL-EPA values may be more restrictive than the federal values. These differences typically reflect differences in toxicity values and not exposure assumptions. Where CAL-Modified values are presented, they should be used for screening purposes within the State of California.

In general, PRG concentrations in the table are risk-based but for soil there are two important exceptions: 1) for several volatile chemicals PRGs are based on soil saturation equation ("sat") (see below), and 2) for relatively less toxic inorganic and semivolatile contaminants, a non-risk based "ceiling limit" concentration is given as 10^{+5} mg/kg "max". PRG concentrations that are not risk-based (i.e. either "sat" or "max") should be segregated before screening multiple pollutant risks.

2.2 Toxicity Values:

EPA toxicity values, known as noncarcinogenic reference doses (RfD) and carcinogenic slope factors (SF) were obtained from IRIS through July 1995, HEAST through November 1994, and ECAO-Cincinnati. The priority among sources of toxicological constants used are as follows: (1) IRIS (indicated by "i"), (2) HEAST ("h"), (3) ECAO ("e"), and (4) withdrawn from IRIS or HEAST and under review ("x").

Route-to-route extrapolations ("r") were frequently used when there were no toxicity values available for a given route of exposure. Oral cancer slope factors ("SFo") and reference doses ("RfDo") were used for both oral and inhaled exposures for organic compounds lacking inhalation values. Also, inhalation slope factors ("SFi") and inhalation reference doses ("RfDi") were frequently used for both inhaled and oral exposures for organic compounds lacking oral values. An additional route extrapolation is the use of oral toxicity values for evaluating dermal exposures. **Although route-to-route methods are a useful screening procedure, the appropriateness of these default assumptions for specific contaminants should be verified by a toxicologist.**

This update contains new toxicity values for arsenic, benzene, 1-chloro-1,1-difluoroethane (HCFC-142b), cobalt, danitol, hydrogen chloride, hydrogen sulfide, methyl mercury, and phosphine. The updated values are indicated in boldface print in the table.

2.3 Soil Factors:

Chemical-specific information for soils, volatilization factors ("VF_s") and skin absorption factors ("ABS"), are listed in the table to provide additional assumptions used to calculate soil PRGs. For volatile chemicals, the "VF_s" term was incorporated into the PRG equations to address long-term inhalation exposures. Volatile organic chemicals (VOCs) are indicated by "1" in the VOC column of the Table and are defined as those chemicals having a Henry's Law constant greater than 10^{-5} ($atm\text{-}m^3/mol$) and a molecular weight less than 200 g/mole).

Chemical-specific soil "ABS" values are provided for arsenic, cadmium, pentachlorophenol, PCBs, and dioxin as recommended by EPA's Office of Research and Development (1994) for the evaluation of contaminant absorption through the skin. Otherwise, default skin absorption fractions are assumed to be 0.01 and 0.10, for inorganics and organics, respectively. Although it is debatable whether a default of 0.10 skin absorption is appropriate for volatile contaminants in soils, it should be noted that in practical terms, this assumption makes little difference in the soil PRG because the risk driver for volatiles is generally based on the soil-to-air pathway and not ingestion or skin contact.

3.0 USING THE PRG TABLE

The decision to use PRGs at a site will be driven by the potential benefits of having generic risk-based concentrations in the absence of site-specific risk assessments. The original intended use of PRGs was to provide initial cleanup goals for individual chemicals given specific medium and land-use combinations (see RAGS Part B, 1991), however risk-based PRGs actually have several uses in addition to providing initial goals. These include:

- Screening sites to determine further evaluation
- Prioritizing areas of concern at megasites (e.g. federal facilities)
- Calculating risks associated with multiple contaminants

A few basic procedures are recommended for using PRGs properly. These are briefly described below. Potential problems with the use of PRGs are also identified.

3.1 Developing a Conceptual Site Model

The primary condition for use of PRGs is that exposure pathways of concern and conditions at the site match those taken into account by the PRG framework. Thus, it is always necessary to develop a conceptual site model (CSM) to identify likely contaminant source areas, exposure pathways, and potential receptors. This information can be used to determine the applicability of PRGs at the site and the need for additional information. For those pathways not covered by PRGs, a risk assessment specific to these additional pathways may be necessary. Nonetheless, the PRG lookup values will still be useful in such situations for focusing further investigative efforts on the exposure pathways not addressed.

To develop a site-specific CSM, perform an extensive records search and compile existing data (e.g. available site sampling data, historical records, aerial photographs, and hydrogeologic information). Once this information is obtained, CSM worksheets such as those provided in ASTM's *Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (1994) can be used to tailor the generic worksheet model to a site-specific CSM. The final CSM diagram represents linkages among contaminant sources, release mechanisms, exposure pathways and routes and receptors. It summarizes our understanding of the contamination problem.

As a final check, the CSM should answer the following questions:

- Are there potential ecological concerns?
- Is there potential for land use other than those covered by the PRGs (that is, residential and industrial)?
- Are there other likely human exposure pathways that were not considered in development of the PRGs (e.g. impact to groundwater, local fish consumption; raising beef, dairy, or other livestock)?
- Are there unusual site conditions (e.g. large areas of contamination, high fugitive dust levels, potential for indoor air contamination)?

If any of these four conditions exist, the PRG may need to be modified to reflect this new information. Suggested references for evaluating pathways not currently evaluated by Region IX PRG's are presented in Exhibit 3-1.

EXHIBIT 3-1

SUGGESTED READINGS FOR EVALUATING SOIL CONTAMINANT PATHWAYS NOT CURRENTLY ADDRESSED BY REGION IX PRGs

EXPOSURE PATHWAY	REFERENCE
Migration of contaminants to an underlying potable aquifer	*Technical Background Document for Soil Screening Guidance - Review Draft* (USEPA 1994c)
Ingestion via plant uptake	*Technical Support Document for Land Application of Sewage Sludge (USEPA 1992a)*
Ingestion via meat or dairy products	*Estimating Exposure to Dioxin-Like Compounds - Review Draft* (1994d)
Inhalation of volatiles that have migrated into basements	*Technical Background Document for Soil Screening Guidance - Review Draft* (USEPA 1994c)
Terrestrial environmental pathways	*Role of the Ecological Risk Assessment in the Baseline Risk Assessment* (USEPA 1994e)

3.2 Background Levels Evaluation

A necessary step in determining the usefulness of Region IX PRGs is the consideration of background contaminant concentrations. EPA may be concerned with two types of background at sites: naturally occurring and anthropogenic. Natural background is usually limited to metals whereas anthropogenic (i.e. human-made) background includes both organic and inorganic contaminants. Before embarking on an extensive sampling and analysis program to determine local background concentrations in the area, one should first compile existing data on the subject. Far too often there is pertinent information in the literature that gets ignored, resulting in needless expenditures of time and money.

Generally EPA does not clean up below natural background. If natural background concentrations are higher than the PRGs, the generic PRGs may not be the best tool for site decisionmaking. Or, an adjustment of the PRG may be needed. For example, naturally occurring arsenic frequently is higher than the soil PRG set equal to a one-in-one-million cancer risk (the point of departure), thus an alternative PRG for arsenic is provided in the lookup tables based on non-cancer endpoints that is still protective of cancer risks as well (i.e. falls within EPA's "acceptable" risk range). Because of the problems associated with adjusting PRGs to an alternate risk level, this procedure is not recommended without first consulting a staff toxicologist at state and / or federal regulatory agencies.

Where anthropogenic background levels exceed PRGs and EPA has determined that a response action is necessary and feasible, EPA's goal will be to develop a comprehensive response to the widespread contamination. This will often require coordination with different authorities that have jurisdiction over the sources of contamination in the area.

3.3 Risk Screening

A suggested stepwise approach for screening sites with PRGs is as follows:

- Perform an extensive records search and compile existing data.

- Identify site contaminants in the PRG Table. Record the PRG concentrations for various media and note whether PRG is based on cancer risk (indicated by "ca") or noncancer hazard (indicated by "nc"). Segregate cancer PRGs from non-cancer PRGs and exclude (but don't eliminate) non-risk based PRGs ("sat" or "max").

- For cancer risk estimates, take the site-specific concentration (maximum or 95 UCL) and divide by the PRG concentrations that are designated for cancer evaluation ("ca"). Multiply this ratio by 10^{-6} to estimate chemical-specific risk. For multiple pollutants, simply add the risk for each chemical :

$$Risk = \left[\left(\frac{conc_x}{PRG_x}\right) + \left(\frac{conc_y}{PRG_y}\right) + \left(\frac{conc_z}{PRG_z}\right)\right] x\ 10^{-6}$$

- For non-cancer hazard estimates. Divide concentration term by its respective non-cancer PRG designated as "nc" and sum the ratios for multiple contaminants. [Note that carcinogens may also have an associated non-cancer PRG that is not listed in the printed copy of the table and these will also need to be obtained in order to complete the non-cancer evaluation.] The non-cancer ratio represents a hazard index (HI). A hazard index of 1 or less is generally considered safe . A ratio greater than 1 suggests further evaluation:

$$Hazard\ Index = \left[\left(\frac{conc_x}{PRG_x}\right) + \left(\frac{conc_y}{PRG_y}\right) + \left(\frac{conc_z}{PRG_z}\right)\right]$$

For more information on screening site risks, the reader should contact EPA Region IX's Technical Support Section.

3. 4 Potential Problems:

As with any risk-based tool, the potential exists for misapplication. In most cases the root cause will be a lack of understanding of the intended use of Region IX PRGs. In order to prevent misuse of PRGs, the following should be avoided:

- Applying PRGs to a site without adequately developing a conceptual site model that identifies relevant exposure pathways and exposure scenarios,

- Not considering background concentrations when choosing PRGs as cleanup goals,

- Use of PRGs as cleanup levels without the nine-criteria analysis specified in the National Contingency Plan (or, comparable analysis for programs outside of Superfund),

- Use of PRGs as cleanup levels without verifying numbers with a toxicologist,

- Use of antiquated PRG tables that have been superseded by more recent publications,
- Not considering the effects of additivity when screening multiple chemicals, and

- Adjusting PRGs upward by factors of 10 or 100 without consulting a toxicologist.

4.0 TECHNICAL SUPPORT DOCUMENTATION

PRGs consider human exposure hazards to chemicals from contact with contaminated soils, air, and water. The emphasis of the PRG equations and technical discussion are aimed at developing initial goals for soils, since this is an area where few standards exist. For air and water, additional reference concentrations or standards are available for many chemicals (e.g. non-zero MCLGs, AWQC, and NAAQS) and consequently the discussion of these media are brief.

4.1 Inhalation of Volatiles and Fugitive Dusts:

Agency toxicity criteria indicate that risks from exposure to some chemicals via inhalation far outweigh the risk via ingestion; therefore soil PRGs have been designed to address this pathway as well. The models used to calculate PRGs for inhalation of volatiles / particulates are updates of risk assessment methods presented in RAGS Part B (USEPA 1991a) and are consistent with the *Technical Background Document for Soil Screening Guidance - Review Draft* (USEPA 1994c).

To address the soil-to-air pathways the PRG calculations incorporate volatilization factors (VF_s) for volatile contaminants and particulate emission factors (PEF) for nonvolatile contaminants. These factors relate soil contaminant concentrations to air contaminant concentrations that may be inhaled on-site. The VF_s and PEF equations can be broken into two separate models: an emission model to estimate emissions of the contaminant from the soil and a dispersion model to simulate the dispersion of the contaminant in the atmosphere.

It should be noted that the box model in RAGS Part B has been replaced with a dispersion term (Q/C) derived from a modeling exercise using meteorological data from 29 locations across the United States because the box model may not be applicable to a broad range of site types and meteorology and does not utilize state-of-the-art techniques developed for regulatory dispersion modeling. The dispersion model for both volatiles and particulates is the AREA-ST, an updated version of the Office of Air Quality Planning and Standards, Industrial Source Complex Model, ISC2. However, different Q/C terms are used in the VF and PEF equations. Los Angeles was selected as the 90th percentile data set for volatiles and Minneapolis was selected as the 90th percentile data set for fugitive dusts (USEPA 1994c). A default source size of 0.5 acres was chosen for the PRG calculations. This is consistent with the default exposure area over which Region IX typically averages contaminant concentrations in soils. This differs from the default (30 acres) assumed in *Technical Background Document for Soil Screening Guidance - Review Draft* (USEPA 1994c). However, based on communications with project managers and technical staff, an assumed contaminant source size of 30 acres was considered inappropriate for most sites. If unusual site conditions exist such that the area source is substantially larger than the default source size assumed here, an alternative Q/C could be applied (see USEPA 1994c).

Volatilization Factor for Soils

Volatile chemicals, defined as those chemicals having a Henry's Law constant greater than 10^{-5} (atm-m^3/mol) and a molecular weight less than 200 g/mole, were screened for inhalation exposures using a volatilization factor for soils (VF_s).

The emission terms used in the VF_s are chemical-specific and were calculated from physical-chemical information obtained from a number of sources including *Superfund Exposure Assessment Manual* (SEAM, EPA 1988), *Superfund Public Health Evaluation Manual* (EPA 1986), *Subsurface Contamination Reference Guide* (EPA 1990a) and *Fate and Exposure Data* (Howard 1991). In those cases where Diffusivity Coefficients (Di) were not provided in existing literature, Di's were calculated using Fuller's Method described in SEAM. A surrogate term was required for some chemicals that lacked physico-

chemical information. In these cases, a proxy chemical of similar structure was used that may over- or under-estimate the PRG for soils. Physical-chemical information is available in the electronic version of the PRG table. To access this information, the user should display the hidden columns in the table.

Equation 4-9 forms the basis for deriving generic soil PRGs for the inhalation pathway. The following parameters in the standardized equation can be replaced with specific site data to develop a simple site-specific PRG

- Source area
- Average soil moisture content
- Average fraction organic carbon content
- Dry soil bulk density

The basic principle of the VF_s model is applicable only if the soil contaminant concentration is at or below soil saturation. Above this level the model cannot predict an accurate VF. If the PRG calculated using VF_s was greater than the calculated "sat" (Equation 4-10), the PRG was set equa "sat" in accordance with Risk Assessment Guidance for Superfund - Part B (EPA, 1991).

Volatilization Factor for Tap Water

For tap water, an upperbound volatilization constant (VF_s) is used that is based on all uses of household water (e.g showering, laundering, and dish washing). Certain assumptions were made. For example, it is assumed that the volume of water used in a residence for a family of four is 720 L/day, the volume of the dwelling is 150,000 L and the air exchange rate is 0.25 air changes/hour (Andelman in RAGS Part B). Furthermore, it is assumed that the average transfer efficiency weighted by water use is 50 percent (i.e. half of the concentration of each chemical in water will be transferred into air by all water uses). Note: the range of transfer efficiencies extends from 30% for toilets to 90% for dishwashers.

Particulate Emission Factor for Soils

Inhalation of chemicals adsorbed to respirable particles (PM_{10}) were assessed using a default PEF equal to 1. 316 x 10^9 m^3/kg that relates the contaminant concentration in soil with the concentration of respirable particles in the air due to fugitive dust emissions from contaminated soils. The relationship is derived by Cowherd (1985) for a rapid assessment procedure applicable to a typical hazardous waste site where the surface contamination provides a relatively continuous and constant potential for emission over an extended period of time (e.g. years). **This may not be an appropriate assumption for all sites.**

The impact of the PEF on the resultant PRG concentration (that combines soil exposure pathways for ingestion, skin contact, and inhalation) can be assessed by downloading the PRG tables and displaying the hidden columns. With the exception of specific heavy metals, the PEF does not appear to significantly affect most soil PRGs. Equation 4-11 forms the basis for deriving a generic PEF for the inhalation pathway. For more details regarding specific parameters used in the PEF model, the reader is referred to *Technical Background Document for Soil Screening Guidance - Review Draft* (December 1994).

Note: the PEF considers windborne emissions and does not consider dust emissions from traffic or other forms of mechanical disturbance.

4.2 Dermal Absorption of Contaminants in Soil:

Much uncertainty surrounds the determination of hazards associated with skin contact with soils. Thus far, chemical-specific absorption values for skin have been recommended for only five chemicals by EPA's Office of Research and Development. For all other chemicals, default absorption values for inorganics and organics are assumed to be 1 and 10 percent, respectively. An additional uncertainty is the lack of toxicity values for the dermal route. For screening purposes it is assumed that dermal toxicity values can be route-to-route extrapolated from oral values but this may not always be an appropriate assumption and should be checked.

At 10 % skin absorption, the dermal dose is estimated to equal an ingestion dose for adults, using the best estimate default values in *Dermal Exposure Assessment: Principles and Applications* (EPA 1992). At 1 % absorption, the dermal dose is estimated to be 10% of the oral dose (i.e. based on an adult ingestion rate of 100 mg/day). Note: worker and children intake rates, 50 mg/day and 200 mg/day,
respectively, yield somewhat different results.

dermal dose = ingestion dose

$$C_{SOIL} \times ABS \times AF \times SA = C_{SOIL} \times IR$$

$$ABS = \frac{(100 mg/day)}{[(0.2 mg/cm^2\text{-}day)\,(5000 cm^2)]} = 0.10$$

4.3 Exposure Factors:

Default exposure factors were obtained primarily from RAGS Supplemental Guidance Standard Default *Exposure Factors* (OSWER Directive, 9285.6-03) dated March 25, 1991 and supplemented with more recent information from U.S. EPA's Office of Solid Waste and Emergency Response, U.S. EPA's Office of Research and Development, and California EPA's Department of Toxic Substances Control (see Exhibit 4-1).

Because contact rates may be different for children and adults, carcinogenic risks during the first 30 years of life were calculated using age-adjusted factors ("adj"). Use of age-adjusted factors are especially important for soil ingestion exposures, which are higher during childhood and decrease with age. However, for purposes of combining exposures across pathways, additional age-adjusted factors are used for inhalation and dermal exposures. These factors approximate the integrated exposure from birth until age 30 combining contact rates, body weights, and exposure durations for two age groups - small children and adults. Age-adjusted factors were obtained from RAGS PART B or developed by analogy (see derivations next page).

For soils only, noncarcinogenic contaminants are evaluated in children separately from adults. No age-adjustment factor is used in this case. The focus on children is considered protective of the higher daily intake rates of soil by children and their lower body weight. For maintaining consistency, when evaluating soils, dermal and inhalation exposures are also based on childhood contact rates.

(1) ingestion([mg•yr]/[kg•d]:

$$IFS_{adj} = \frac{ED_c \times IRS_c}{BW_c} + \frac{(ED_r - ED_c) \times IRS_a}{BW_a}$$

(2) skin contact([mg•yr]/[kg•d]:

$$SFS_{adj} = \frac{ED_c \times AF \times SA_c}{BW_c} + \frac{(ED_r - ED_c) \times AF \times SA_a}{BW_a}$$

(3) inhalation ([m^3•yr]/[kg•d]):

$$InhF_{adj} = \frac{ED_c \times IRA_c}{BW_c} + \frac{(ED_r - ED_c) \times IRA_a}{BW_a}$$

4.4 PRG Equations:

The equations used to calculate the PRGs for carcinogenic and noncarcinogenic contaminants are presented in Equations 4-1 through 4-8. The PRG equations update RAGS Part B equations. Briefly, PRGs are risk assessments run in reverse. The methodology backcalculates a soil, air, or water concentration level from a target risk (for carcinogens) or hazard quotient (for noncarcinogens). For completeness, the soil equations combine risks from ingestion, skin contact, and inhalation simultaneously. Note: the electronic version of the table also includes route-specific PRGs that are similar to OSWER's Soil Screening Levels (EPA 1994c), should the user decide against combining specific exposure pathways or wants to identify the relative contribution of each pathway to the resulting contaminant concentration in soil.

To calculate PRGs for volatile chemicals in soil, a chemical-specific volatilization factor is calculated per Equation 4-9. Because of its reliance on Henry's law, the VF model is applicable only when the contaminant concentration in soil water is at or below saturation (i.e. there is no free-phase contaminant present). This corresponds to the contaminant concentration in soil at which the adsorptive limits of the soil particles and the solubility limits of the available soil moisture have been reached. Above this point, pure liquid-phase contaminant is expected in the soil. The updated equation for deriving (sat) is presented in Equation 4-10. Note that it supersedes the equation presented in RAGS Part B.

EXHIBIT 4-1
STANDARD DEFAULT FACTORS

Symbol	Definition (units)	Default	Reference
CSFo	Cancer slope factor oral (mg/kg-d)-1	–	IRIS, HEAST, or ECAO
CSFi	Cancer slope factor inhaled (mg/kg-d)-1	–	IRIS, HEAST, or ECAO
RfDo	Reference dose oral (mg/kg-d)	–	IRIS, HEAST, or ECAO
RfDi	Reference dose inhaled (mg/kg-d)	–	IRIS, HEAST, or ECAO
TR	Target cancer risk	10^{-6}	–
THQ	Target hazard quotient	1	–
BWa	Body weight, adult (kg)	70	RAGS (Part A), EPA 1989 (EPA/540/1-89/002)
BWc	Body weight, child (kg)	15	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
ATc	Averaging time - carcinogens (days)	25550	RAGS(Part A), EPA 1989 (EPA/540/1-89/002)
ATn	Averaging time - noncarcinogens (days)	ED*365	
SAa	25% Surface area, adult (cm^2/day)	5000	Dermal Assessment, EPA 1992 (EPA/600/8-91/011B)
SAc	25% Surface area, child (cm^2/day)	2000	Dermal Assessment, EPA 1992 (EPA/ 600/8-9/011B)
AF	Adherence factor (mg/cm^2)	0.2	Dermal Assessment, EPA 1992 (EPA/ 600/8-9/011B)
ABS	Skin absorption (unitless):		
	– organics	0.1	PEA, Cal-EPA (DTSC, 1994)
	–Inorganics	0.01	PEA, Cal-EPA (DTSC, 1994)
IRAa	Inhalation rate - adult (m^3/day)	20	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
IRAc	Inhalation rate - child (m^3/day)	10	RAGS (Part A), EPA 1989 (EPA/540/1-89/002)
IRWa	Drinking water ingestion - adult (L/day	2	RAGS(Part A), EPA 1989 (EPA/540/1-89/002)
IRWc	Drinking water ingestion - child (L/day)	1	PEA, Cal-EPA (DTSC, 1994)
IRSa	Soil ingestion - adult (mg/day)	100	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
IRSc	Soil ingestion - child (mg/day),	200	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
IRSo	Soil ingestion - occupational (mg/day)	50	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
EFr	Exposure frequency - residential (d/y)	350	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
EFo	Exposure frequency - occupational (d/y)	250	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
EDr	Exposure duration - residential (years)	30[a]	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
EDc	Exposure duration - child (years)	6	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
EDo	Exposure duration - occupational (years)	25	Exposure Factors , EPA 1991 (OSWER No. 9285.6-03)
	Age-adjusted factors for carcinogens:		
IFSadj	Ingestion factor, soils ([mg•yr]/[kg•d])	114	RAGS(Part B) , EPA 1991 (OSWER No. 9285.7-01B)
SFSadj	Skin contact factor, soils ([mg•yr]/[kg•d])	503	By analogy to RAGS (Part B)
InhFadj	Inhalation factor ([m^3•yr]/[kg•d])	11	By analogy to RAGS (Part B)
IFWadj	Ingestion factor, water ([l•yr]/[kg•d])	1.1	By analogy to RAGS (Part B)
VFw	Volatilization factor for water (L/m^3)	0.5	RAGS(Part B) , EPA 1991 (OSWER No. 9285.7-01B)
PEF	Particulate emission factor (m^3/kg)	See below	Technical Background Document for Draft SSL (EPA 1994)
VFs	Volatilization factor for soil (m^3/kg)	See below	Technical Background Document for Draft SSL (EPA 1994)
sat	Soil saturation concentration (mg/kg)	See below	Technical Background Document for Draft SSL (EPA 1994)

Footnote:
[a]Exposure duration for lifetime residents is assumed to be 30 years total. For carcinogens, exposures are combined for children (6 years) and adults (24 years) .

PRG EQUATIONS

Soil Equations: For soils, equations were based on three exposure routes (ingestion, skin contact, and inhalation).

Equation 4-1: Combined Exposures to Carcinogenic Contaminants in Residential Soil

$$C(mg/kg) = \frac{TR \times AT_c}{EF_r \left[\left(\frac{IFS_{adj} \times CSF_o}{10^6 mg/kg} \right) + \left(\frac{SFS_{adj} \times ABS \times CSF_o}{10^6 mg/kg} \right) + \left(\frac{InhF_{adj} \times CSF_i}{VF_s^a} \right) \right]}$$

Equation 4-2: Combined Exposures to Noncarcinogenic Contaminants in Residential Soil

$$C(mg/kg) = \frac{THQ \times BW_c \times AT_n}{EF_r \times ED_c \left[\left(\frac{1}{RfD_o} \times \frac{IRS_c}{10^6 mg/kg} \right) + \left(\frac{1}{RfD_o} \times \frac{SA_c \times AF \times ABS}{10^6 mg/kg} \right) + \left(\frac{1}{RfD_i} \times \frac{IRA_c}{VF_s^a} \right) \right]}$$

Equation 4-3: Combined Exposures to Carcinogenic Contaminants in Industrial Soil

$$C(mg/kg) = \frac{TR \times BW_a \times AT_c}{EF_o \times ED_o \left[\left(\frac{IRS_o \times CSF_o}{10^6 mg/kg} \right) + \left(\frac{SA_a \times AF \times ABS \times CSF_o}{10^6 mg/kg} \right) + \left(\frac{IRA_a \times CSF_i}{VF_s^a} \right) \right]}$$

Equation 4-4: Combined Exposures to Noncarcinogenic Contaminants in Industrial Soil

$$C(mg/kg) = \frac{THQ \times BW_a \times AT_n}{EF_o \times ED_o \left[\left(\frac{1}{RfD_o} \times \frac{IRS_o}{10^6 mg/kg} \right) + \left(\frac{1}{RfD_o} \times \frac{SA_a \times AF \times ABS}{10^6 mg/kg} \right) + \left(\frac{1}{RfD_i} \times \frac{IRA_a}{VF_s^a} \right) \right]}$$

Footnote:

[a] Use VF_s for volatile chemicals (defined as having a Henry's Law Constant [atm-m^3/mol] greater than 10^{-5} and a molecular weight less than 200 grams/mol) or PEF for non-volatile chemicals.

Tap Water Equations:

Equation 4-5: Ingestion and Inhalation Exposures to Carcinogenic Contaminants in Water

$$C(ug/L) = \frac{TR \times AT_c \times 1000ug/mg}{EF_r\ [(IFW_{adj} \times CSF_o) + (VF_w \times InhF_{adj} \times CSF_i)]}$$

Equation 4-6: Ingestion and Inhalation Exposures to Noncarcinogenic Contaminants in Water

$$C(ug/L) = \frac{THQ \times BW_a \times AT_n \times 1000ug/mg}{EF_r \times ED_r\ [(\frac{IRW_a}{RfD_o}) + (\frac{VF_w \times IRA_a}{RfD_i})]}$$

Air Equations:

Equation 4-7: Inhalation Exposures to Carcinogenic Contaminants in Air

$$C(ug/m^3) = \frac{TR \times AT_c \times 1000ug/mg}{EF_r \times InhF_{adj} \times CSF_i}$$

Equation 4-8: Inhalation Exposures to Noncarcinogenic Contaminants in Air

$$C(ug/m^3) = \frac{THQ \times RfD_i \times BW_a \times AT_n \times 1000ug/mg}{EF_r \times ED_r \times IRA_a}$$

SOIL-TO-AIR VOLATILIZATION FACTOR (VF_s)

Equation 4-9: Derivation of the Volatilization Factor

$$VF_s(m^3/kg) = (Q/C) \times \frac{(3.14 \times \alpha \times T)^{1/2}}{(2 \times D_{ei} \times \theta_a \times K_{as})} \times 10^{-4} m^2/cm^2$$

where:

$$\alpha = \frac{D_{ei} \times \theta_a}{\theta_a + [(\rho_s)(1-\theta_a)/K_{as}]}$$

Parameter	Definition (units)	Default
VF_s	Volatilization factor (m^3/kg)	--
Q/C	Inverse of the mean conc. at the center of a 0.5-acre square source (g/m^2-s per kg/m^3)	68.81
T	Exposure interval (s)	7.9×10^8
Dei	Effective diffusivity (cm^2/s)	$Di(\theta_a^{3.33}/n^2)$
θ_a	Air filled soil porosity (L_{air}/L_{soil})	0.28 or $n\text{-}w\rho_b$
Di	Diffusivity in air (cm^2/s)	Chemical-specific
n	Total soil porosity (L_{pore}/L_{soil})	0.43 (loam)
w	Average soil moisture content (g_{water}/g_{soil} or cm^3_{water}/g_{soil})	0.1
ρ_b	Dry soil bulk density (g/cm^3)	1.5 or $(1 - n)\rho_s$
ρ_s	Soil particle density (g/cm^3)	2.65
K_{as}	Soil-air partition coefficient (g-soil/cm^3-air)	(H/Kd) x 41 (41 is a conversion factor)
H	Henry's Law constant (atm-m^3/mol)	Chemical-specific
K_d	Soil-water partition coefficient (cm^3/g)	$K_{oc} \times f_{oc}$
k_{oc}	Soil organic carbon/water partition coefficient (cm^3/g)	Chemical-specific
f_{oc}	Fraction organic carbon content of soil (g/g)	0.02 or site-specific

SOIL SATURATION CONCENTRATION (sat)

Equation 4-10: Derivation of the Soil Saturation Limit

$$sat = \frac{S}{\rho_b} \left(K_d \rho_b + \theta_w + H' \theta_a\right)$$

Parameter	Definition (units)	Default
sat	Soil saturation concentration (mg/kg)	–
S	Solubility in water (mg/L-water)	Chemical-specific
ρ_b	Dry soil bulk density (kg/L)	1.5 or $(1 - n)\rho_s$
n	Total soil porosity (L_{pore}/L_{soil})	0.43 (loam)
ρ_s	Soil particle density (kg/L)	2.65
K_d	Soil-water partition coefficient (L/kg)	$K_{oc} \times f_{oc}$ (organics)
k_{oc}	Soil organic carbon/water partition coefficient (L/kg)	Chemical-specific
f_{oc}	Fraction organic carbon content of soil (g/g)	0.02 or site-specific
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15 or $w\rho_b$
θ_a	Air filled soil porosity (L_{air}/L_{soil})	0.28 or $n\text{-}w\rho_b$
w	Average soil moisture content (kg_{water}/kg_{soil} or L_{water}/kg_{soil})	0.1
H'	Henry's Law constant (unitless)	H x 41, where 41 is a units conversion factor
H	Henry's Law constant (atm-m^3/mol)	Chemical-specific

SOIL-TO-AIR PARTICULATE EMISSION FACTOR (PEF)

Equation 4-11: Derivation of the Particulate Emission Factor

$$PEF(m^3/kg) = Q/C \times \frac{3600 s/h}{0.036 \times (1-V) \times (U_m/U_t)^3 \times F(x)}$$

Parameter	Definition (units)	Default
PEF	Particulate emission factor (m^3/kg)	1. 316 x 10^9
Q/C	Inverse of the mean concentration at the center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	90.80
V	Fraction of vegetative cover (unitless)	0.5
U_m	Mean annual windspeed (m/s)	4.69
U_t	Equivalent threshold value of windspeed at 7 m (m/s)	11.32
F(x)	Function dependent on U_m/U_t derived using Cowherd (1985) (unitless)	0.194

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Key : l=RfS h=HEAST e=ECAO x=WITHDRAWN r=ROUTE EXTRAPOLATION ca=CANCER PRG nc=NONCANCER PRG sat=SOIL SATURATION max=CEILING LIMIT *(where: nc < 100X ca) **(where: nc < 10X ca)
FOR PLANNING PURPOSES

TOXICITY VALUES				SOIL FACTORS			CONTAMINANT		PRELIMINARY REMEDIAL GOALS (PRGs)			
SFo 1/(mg/kg-d)	RfDo (mg/kg-d)	SFI 1/(mg/kg-d)	RfDI (mg/kg-d)	VOC	skin ABS	VF (m^3/kg)	CAS No.		Residential Soil (mg/kg)	Industrial Soil (mg/kg)	Ambient Air (ug/m^3)	Tap Water (ug/l)
6.7E-03 l	4.0E-03 l	6.7E-03 r	4.0E-03 r	0	0.10		30560-19-1	Acephate	5.1E+01 ca**	2.2E+02 ca*	7.7E-01 ca*	7.7E+00 ca*
			2.6E-03 l	0	0.10		75-07-0	Acetaldehyde			9.4E+00 nc	
	2.0E-02 l		2.0E-02 r	0	0.10		34256-82-1	Acetochlor	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	1.0E-01 l		1.0E-01 r	1	0.10	1.9E+04	67-64-1	Acetone	2.0E+03 nc	8.4E+03 nc	3.7E+02 nc	6.1E+02 nc
	8.0E-04 h		2.6E-03 x	0	0.10		75-86-5	Acetone cyanohydrin	5.2E+01 nc	5.5E+02 nc	1.0E+01 nc	2.9E+01 nc
	6.0E-03 l		1.4E-02 h	0	0.10		75-05-8	Acetonitrile	3.9E+02 nc	4.1E+03 nc	5.2E+01 nc	2.2E+02 nc
	1.0E-01 l		5.7E-06 x	0	0.10		98-86-2	Acetophenone	4.2E+03 nc	2.5E+04 nc	2.1E-02 nc	3.7E+03 nc
	1.3E-02 l		1.3E-02 r	0	0.10		50594-66-6	Acifluorfen	8.5E+02 nc	8.9E+03 nc	4.7E+01 nc	4.7E+02 nc
	2.0E-02 h		5.7E-06 l	0	0.10		107-02-8	Acrolein	1.2E+03 nc	1.0E+04 nc	2.1E-02 nc	7.3E+02 nc
4.5E+00 l	2.0E-04 l	4.5E+00 l	2.0E-04 r	0	0.10		79-06-1	Acrylamide	9.6E-02 ca*	4.2E-01 ca	1.5E-03 ca	1.5E-02 ca
	5.0E-01 l		8.6E-04 l	C	0.10		79-10-7	Acrylic acid	3.2E+04 nc	3.2E+05 nc	3.1E+00 nc	1.8E+04 nc
5.4E-01 l	1.0E-03 h	2.4E-01 l	5.7E-04 l	1	0.10	5.4E+03	107-13-1	Acrylonitrile	1.3E-01 ca*	3.0E-01 ca*	2.8E-02 ca*	3.7E+00 ca*
8.1E-02 h	1.0E-02 l	8.0E-02 r	1.0E-02 r	0	0.10		15972-60-8	Alachlor	5.5E+00 ca*	2.4E+01 ca	8.4E-02 ca	8.4E-01 ca
	1.5E-01 l		1.5E-01 r	0	0.10		1596-84-5	Alar	9.8E+03 nc	1.0E+05 nc	5.5E+02 nc	5.5E+03 nc
	1.0E-03 l		1.0E-03 r	0	0.10		116-06-3	Aldicarb	6.5E+01 nc	6.8E+02 nc	3.7E+00 nc	3.7E+01 nc
	1.0E-03 l		1.0E-03 r	0	0.10		1646-88-4	Aldicarb sulfone	6.5E+01 nc	6.8E+02 nc	3.7E+00 nc	3.7E+01 nc
1.7E+01 l	3.0E-05 l	1.7E+01 l	3.0E-05 r	0	0.10		309-00-2	Aldrin	2.6E-02 ca*	1.1E-01 ca	3.9E-04 ca	4.0E-03 ca
	2.5E-01 l		2.5E-01 r	0	0.10		5585-64-6	Ally	1.6E+04 nc	1.0E+05 max	9.1E+02 nc	9.1E+03 nc
	5.0E-03 x		5.0E-03 r	0	0.10		107-18-6	Allyl alcohol	3.3E+02 nc	3.4E+03 nc	1.8E+01 nc	1.8E+02 nc
	5.0E-02 h		2.8E-04 l	0	0.10		107-05-1	Allyl chloride	3.2E+03 nc	3.3E+04 nc	1.0E+00 nc	1.8E+03 nc
	1.0E+00 e			0	0.01		7429-90-5	Aluminum	7.7E+04 nc	1.0E+05 max		3.7E+04 nc
	4.0E-04 l			0	0.01		20859-73-8	Aluminum phosphide	3.1E+01 nc	8.8E+02 nc		1.5E+01 nc
	3.0E-04 l		3.0E-04 r	0	0.10		67485-29-4	Amdro	2.0E+01 nc	2.0E+02 nc	1.1E+00 nc	1.1E+01 nc
	9.0E-03 l		9.0E-03 r	0	0.10		834-12-8	Ametryn	5.9E+02 nc	6.1E+03 nc	3.3E+01 nc	3.3E+02 nc
	7.0E-02 h		7.0E-02 r	0	0.10		591-27-5	m-Aminophenol	4.8E+03 nc	4.9E+04 nc	2.6E+02 nc	2.6E+03 nc
	2.0E-05 h		2.0E-05 r	0	0.10		504-24-5	4-Aminopyridine	1.3E+00 nc	1.4E+01 nc	7.3E-02 nc	7.3E-01 nc
	2.5E-03 l		2.5E-03 r	0	0.10		33089-61-1	Amitraz	1.6E+02 nc	1.7E+03 nc	9.1E+00 nc	9.1E+01 nc
			2.9E-02 l	0	0.10		7664-41-7	Ammonia			1.0E+02 nc	
	2.0E-01 l			0	0.10		7773-06-0	Ammonium sulfamate	1.3E+04 nc	1.0E+05 max		7.3E+03 nc
5.7E-03 l	2.9E-04 r	5.7E-03 r	2.9E-04 l	0	0.10		62-53-3	Aniline	1.9E+01 nc	2.0E+02 nc	1.0E+00 nc	1.1E+01 nc
	4.0E-04 l			0	0.01		7440-36-0	Antimony and compounds	3.1E+01 nc	8.8E+02 nc		3E+01 nc
	6.0E-04 h			0	0.01		1314-60-9	Antimony pentoxide	3.8E+01 nc	8.5E+02 nc		1.8E+01 nc
	9.0E-04 h			0	0.01		28300-74-5	Antimony potassium tartrate	6.9E+01 nc	1.5E+03 nc		3.3E+01 nc
	4.0E-04 h			0	0.01		1332-81-6	Antimony tetroxide	3.1E+01 nc	8.8E+02 nc		1.5E+01 nc
	4.0E-04 h			0	0.01		1309-64-4	Antimony trioxide	3.1E+01 nc	8.8E+02 nc		1.5E+01 nc
	1.3E-02 l		1.3E-02 r	0	0.10		74115-24-5	Apollo	8.5E+02 nc	8.9E+03 nc	4.7E+01 nc	4.7E+02 nc
2.5E-02 l	5.0E-02 h	2.5E-02 l	5.0E-02 r	0	0.10		140-57-8	Aramite	1.8E+01 ca*	7.8E+01 ca	2.7E-01 ca	2.7E+00 ca
	3.0E-04 l			0	0.03		7440-38-2	Arsenic (noncancer endpoint)	2.2E+01 nc			
1.5E+00 l	3.0E-04 l	1.5E+01 l		0	0.03		7440-38-2	Arsenic (cancer endpoint)	3.8E-01 ca*	2.4E+00 ca	4.5E-04 ca	4.5E-02 ca
			1.4E-05 l	0	NA		7784-42-1	Arsine			5.2E-02 nc	
	9.0E-03 l		9.0E-03 r	0	0.10		76578-12-6	Assure	5.9E+02 nc	6.1E+03 nc	3.3E+01 nc	3.3E+02 nc
	5.0E-02 l		5.0E-02 r	0	0.10		3337-71-1	Asulam	3.3E+03 nc	3.4E+04 nc	1.8E+02 nc	1.8E+03 nc
2.2E-01 h	3.5E-02 h	2.2E-01 r	3.5E-02 h	0	0.10		1912-24-9	Atrazine	2.0E+00 ca	8.6E+00 ca	3.1E-02 ca	3.0E-01 ca
	4.0E-04 l		4.0E-04 r	0	0.10		71751-41-2	Avermectin B1	2.6E+01 nc	2.7E+02 nc	1.5E+00 nc	1.5E+01 nc
1.1E-01 l		1.1E-01 l		0	0.10		103-33-3	Azobenzene	4.0E+00 ca	1.7E+01 ca	8.2E-02 ca	8.1E-01 ca
	7.0E-02 l		1.4E-04 h	0	0.01		7440-39-3	Barium and compounds	5.3E+03 nc	1.0E+05 max	5.2E-01 nc	2.6E+03 nc
	4.0E-03 l		4.0E-03 r	0	0.10		114-26-1	Baygon	2.6E+02 nc	2.7E+03 nc	1.5E+01 nc	1.5E+02 nc
	3.0E-02 l		3.0E-02 r	0	0.10		43121-43-3	Bayleton	2.0E+03 nc	2.0E+04 nc	1.1E+02 nc	1.1E+03 nc
	2.5E-02 l		2.5E-02 r	0	0.10		66359-37-5	Baythroid	1.6E+03 nc	1.7E+04 nc	9.1E+01 nc	9.1E+02 nc
	3.0E-01 l		3.0E-01 r	0	0.10		1861-40-1	Benefin	2.0E+04 nc	1.0E+05 max	1.1E+03 nc	1.1E+04 nc
	5.0E-02 l		5.0E-02 r	0	0.10		17804-35-2	Benomyl	3.3E+03 nc	3.4E+04 nc	1.8E+02 nc	1.8E+03 nc
	2.5E-03 l		2.5E-03 r	0	0.10		25057-89-0	Bentazon	1.6E+02 nc	1.7E+03 nc	9.1E+00 nc	9.1E+01 nc
	1.0E-01 l		1.0E-01 r	0	0.10		100-52-7	Benzaldehyde	6.5E+03 nc	6.8E+04 nc	3.7E+02 nc	3.7E+03 nc
2.9E-02 l	1.7E-03 r	2.9E-02 l	1.7E-03 e	1	0.10	6.7E+03	71-43-2	Benzene	1.4E+00 ca*	3.2E+00 ca*	2.3E-01 ca*	3.9E-01 ca*
2.3E+02 l	3.0E-03 l	2.3E+02 l	3.0E-03 r	0	0.10		92-87-5	Benzidine	1.9E-03 ca	8.3E-03 ca	2.9E-05 ca	2.9E-04 ca
	4.0E+00 l		4.0E+00 l	0	0.10		65-85-0	Benzoic acid	1.0E+05 max	1.0E+05 max	1.5E+04 nc	1.5E+05 nc
1.3E+01 l		1.3E+01 r		0	0.10		98-07-7	Benzotrichloride	3.4E-02 ca	1.5E-01 ca	5.2E-04 ca	5.2E-03 ca
	3.0E-01 h		3.0E-01 r	0	0.10		100-51-6	Benzyl alcohol	2.0E+04 nc	1.0E+05 max	1.1E+03 nc	1.1E+04 nc
1.7E-01 l		1.7E-01 r		1	0.10	7.1E+04	100-44-7	Benzyl chloride	1.4E+00 ca	3.9E+00 ca	4.0E-02 ca	6.6E-02 ca
4.3E+00 l	5.0E-03 l	8.4E+00 l		0	0.01		7440-41-7	Beryllium and compounds	1.4E-01 ca	1.1E+00 ca	8.0E-04 ca	1.8E-02 ca
	1.0E-04 l		1.0E-04 r	0	0.10		141-66-2	Bidrin	6.5E+00 nc	6.8E+01 nc	3.7E-01 **	3.7E+00 nc
	.5E-02 l		1.5E-02 r	0	0.10		82657-04-3	Biphenthrin (Ta	9.8E+02 nc	1.0E+04 nc	5.5E+[illegible]	5.5E+02 nc
	.0E-02 l		5.0E-02 r	0	0.10		92-52-4	1,1-Biphenyl	3.3E+03 nc	3.4E+04 nc	1.8E+[illegible]	1.8E+03 nc

1.1E+00 l		1.2E+00 l		1	0.10	1.5E+04	111-44-4	Bis(2-chloroethyl)ether	7.4E-02 ca	1.7E-01 ca	5.8E-03 ca	9.8E-03 ca
7.0E-02 h	4.0E-02 l	3.5E-02 h	4.0E-02 r	1	0.10	5.4E+04	39638-32-9	Bis(2-chloroisopropyl) ether	3.9E+00 ca	1.2E+01 ca	1.9E-01 ca	2.7E-01 ca
2.2E+02 l		2.2E+02 l		1	0.10	4.7E+03	542-88-1	Bis(chloromethyl)ether	1.4E-04 ca	3.0E-04 ca	3.1E-05 ca	5.2E-05 ca
7.0E-02 x		7.0E-02 x		0	0.10		108-60-1	Bis(2-chloro-1-methylethyl)ether	6.3E+00 ca	2.7E+01 ca	9.6E-02 ca	9.6E-01 ca
1.4E-02 l	2.0E-02 l	1.4E-02 r	2.2E-02 r	0	0.10		117-81-7	Bis(2-ethylhexyl)phthalate (DEHP)	3.2E+01 ca*	1.4E+02 ca	4.8E-01 ca	4.8E+00 ca
	5.0E-02 l		5.0E-02 r	0	0.10		80-05-7	Bisphenol A	3.3E+03 nc	3.4E+04 nc	1.6E+02 nc	1.6E+03 nc
	9.0E-02 l		5.7E-03 h	0	0.10		7440-42-8	Boron	5.8E+03 nc	6.1E+04 nc	2.1E+01 nc	3.3E+03 nc
			2.0E-04 h	0	0.10		7637-07-2	Boron trifluoride			7.3E-01 nc	
6.2E-02 l	2.0E-02 l	6.2E-02 r	2.0E-02 r	1	0.10	1.6E+04	75-27-4	Bromodichloromethane	1.4E+00 ca	3.4E+00 ca	1.1E-01 ca	1.8E-01 ca
1.1E-01 r	8.6E-04 r	1.1E-01 h	8.6E-04 l	1	0.10	8.3E+03	593-60-2	Bromoethene (vinyl bromide)	4.5E-01 ca*	1.0E+00 ca*	6.1E-02 ca*	1.0E-01 ca*
7.9E-03 l	2.0E-02 l	3.9E-03 l	2.0E-02 r	0	0.10		75-25-2	Bromoform (tribromomethane)	5.6E+01 ca**	2.4E+02 ca*	1.7E+00 ca*	8.5E+00 ca*
	1.4E-03 l		1.4E-03 l	1	0.10	8.3E+03	74-83-9	Bromomethane	1.5E+01 nc	5.7E+01 nc	5.2E+00 nc	8.7E+00 nc
				0	0.10		101-55-3	4-Bromophenyl phenyl ether				
	5.0E-03 h		5.0E-03 r	0	0.10		2104-96-3	Bromophos	3.3E+02 nc	3.4E+03 nc	1.6E+01 nc	1.6E+02 nc
	2.0E-02 l		2.0E-02 r	0	0.10		1689-84-5	Bromoxynil	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	1.6E+02 nc
	2.0E-02 l		2.0E-02 r	0	0.10		1689-99-2	Bromoxynil octanoate	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
9.8E-01 r		9.8E-01 l		1	0.10	1.3E+03	106-99-0	1,3-Butadiene	8.6E-03 ca	1.8E-02 ca	8.9E-03 ca	1.1E-02 ca
	1.0E-01 l		1.0E-01 r	0	0.10		71-36-3	1-Butanol	6.5E+03 nc	6.8E+04 nc	3.7E+02 nc	3.7E+03 nc
	5.0E-02 l		5.0E-02 r	0	0.10		2008-41-5	Butylate	3.3E+03 nc	3.4E+04 nc	1.6E+02 nc	1.6E+03 nc
	2.0E-01 l		2.0E-01 r	0	0.10		85-68-7	Butyl benzyl phthalate	1.3E+04 nc	1.0E+05 max	7.3E+02 nc	7.3E+03 nc
	1.0E+00 l		1.0E+00 r	0	0.10		85-70-1	Butylphthalyl butylglycolate	6.5E+04 nc	1.0E+05 max	3.7E+03 nc	3.7E+04 nc
	3.0E-03 h		3.0E-03 r	0	0.10		75-60-5	Cacodylic acid	2.0E+02 nc	2.0E+03 nc	1.1E+01 nc	1.1E+02 nc
	5.0E-04 l	6.3E+00 l		0	0.01		7440-43-9	Cadmium and compounds	3.6E+01 nc	8.5E+02 nc	1.1E-03 ca	1.6E+01 nc
								CAL-Modified PRG (PEA, 1994)	9.0E+00			
	5.0E-01 l		5.0E-01 r	0	0.10		105-60-2	Caprolactam	3.3E+04 nc	1.0E+05 max	1.6E+03 nc	1.6E+04 nc
8.6E-03 h	2.0E-03 l	8.6E-03 r	2.0E-03 r	0	0.10		2425-06-1	Captafol	5.2E+01 ca**	2.2E+02 ca*	7.6E-01 ca*	7.6E+00 ca*
3.5E-03 h	1.3E-01 l	3.5E-03 r	1.3E-01 r	0	0.10		133-06-2	Captan	1.3E+02 ca*	5.5E+02 ca	1.9E+00 ca	1.9E+01 ca
	1.0E-01 l		1.1E-01 r	0	0.10		63-25-2	Carbaryl	6.5E+03 nc	6.8E+04 nc	4.0E+02 nc	3.7E+03 nc
2.0E-02 h		2.0E-02 r		0	0.10		86-74-8	Carbazole	2.2E+01 ca	9.5E+01 ca	3.4E-01 ca	3.4E+00 ca
	5.0E-03 l		5.0E-03 r	0	0.10		1563-66-2	Carbofuran	3.3E+02 nc	3.4E+03 nc	1.6E+01 nc	1.6E+02 nc
	1.0E-01 l		2.9E-03 h	1	0.10	3.6E+03	75-15-0	Carbon disulfide	1.6E+01 nc	5.2E+01 nc	1.0E+01 nc	2.1E+01 nc
1.3E-01 l	7.0E-04 l	5.3E-02 l	5.7E-04 e	1	0.10	4.3E+03	56-23-5	Carbon tetrachloride	4.7E-01 ca*	1.1E+00 ca*	1.3E-01 ca*	1.7E-01 ca*
	1.0E-02 l		1.0E-02 r	0	0.10		55285-14-8	Carbosulfan	6.5E+02 nc	6.8E+03 nc	3.7E+01 nc	3.7E+02 nc
	1.0E-01 l		1.0E-01 r	0	0.10		5234-68-4	Carboxin	6.5E+03 nc	6.8E+04 nc	3.7E+02 nc	3.7E+03 nc
	2.0E-03 l		2.0E-03 r	0	0.10		302-17-0	Chloral	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
	1.5E-02 l		1.5E-02 r	0	0.10		133-90-4	Chloramben	9.6E+02 nc	1.0E+04 nc	5.5E+01 nc	5.5E+02 nc
4.0E-01 h		4.0E-01 r		0	0.10		118-75-2	Chloranil	1.1E+00 ca	4.7E+00 ca	1.7E-02 ca	1.7E-01 ca
1.3E+00 l	6.0E-05 l	1.3E+00 l	6.0E-05 r	0	0.10		57-74-9	Chlordane	3.4E-01 ca**	1.5E+00 ca*	5.2E-03 ca*	5.2E-02 ca*
	2.0E-02 l		2.0E-02 r	0	0.10		90982-32-4	Chlorimuron-ethyl	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	1.0E-01 l			0	0.01		7782-50-5	Chlorine	7.7E+03 nc	1.7E+05 nc		3.7E+03 nc
			5.7E-05 l	1	0.10		10049-04-4	Chlorine dioxide			2.1E-01 nc	
				1	0.10		107-20-0	Chloroacetaldehyde				
	2.0E-03 h		2.0E-03 r	0	0.10		79-11-8	Chloroacetic acid	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
	8.6E-06 r		8.6E-06 l	1	0.10	6.4E+03	532-27-4	2-Chloroacetophenone	7.5E-02 nc	2.7E-01 nc	3.1E-02 nc	5.2E-02 nc
	4.0E-03 l		4.0E-03 r	0	0.10		106-47-8	4-Chloroaniline	2.6E+02 nc	2.7E+03 nc	1.5E+01 nc	1.5E+02 nc
	2.0E-02 l		5.7E-03 h	1	0.10	2.1E+04	108-90-7	Chlorobenzene	1.6E+02 nc	5.7E+02 nc	2.1E+01 nc	3.9E+01 nc
2.7E-01 h	2.0E-02 l	2.7E-01 h	2.0E-02 r	0	0.10		510-15-6	Chlorobenzilate	1.6E+00 ca	7.1E+00 ca	2.5E-02 ca	2.5E-01 ca
	2.0E-01 h		2.0E-01 r	0	0.10		74-11-3	p-Chlorobenzoic acid	1.3E+04 nc	1.0E+05 max	7.3E+02 nc	7.3E+03 nc
	2.0E-02 h		2.0E-02 r	0	0.10		98-56-6	4-Chlorobenzotrifluoride	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	2.0E-02 h		2.0E-03 h	1	0.10	2.0E+03	126-99-8	2-Chloro-1,3-butadiene	6.3E+00 nc	2.1E+01 nc	7.3E+00 nc	1.4E+01 nc
	4.0E-01 h		4.0E-01 r	1	0.10	2.0E+03	109-69-3	1-Chlorobutane	1.0E+03 sat	1.0E+03 sat	1.5E+03 nc	2.4E+03 nc
	1.4E+01 r		1.4E+01 l	1	0.10	1.3E+03	75-45-6	1-Chloro-1,1-difluoroethane (HCFC-142b)	5.7E+02 sat	5.7E+02 sat	5.2E+04 nc	8.7E+04 nc
				1	0.10		110-75-8	2-Chloroethyl vinyl ether				
	1.4E+01 r		1.4E+01 l	1	0.10	1.3E+03	75-45-6	Chlorodifluoromethane	5.7E+02 sat	5.7E+02 sat	5.1E+04 nc	8.5E+04 nc
6.1E-03 l	1.0E-02 l	6.1E-02 l	1.0E-02 r	1	0.10	8.4E+03	67-66-3	Chloroform	5.3E-01 ca	1.1E+00 ca	8.4E-02 ca	1.6E-01 ca
1.3E-02 h		6.3E-03 h		1	0.10	2.0E+03	74-87-3	Chloromethane	2.0E+00 ca	4.3E+00 ca	1.1E+00 ca	1.5E+00 ca
5.6E-01 h		5.6E-01 r		0	0.10		95-69-2	4-Chloro-2-methylaniline	7.7E-01 ca	3.3E+00 ca	1.2E-02 ca	1.2E-01 ca
4.6E-01 h		4.6E-01 r		0	0.10		3165-93-3	4-Chloro-2-methylaniline hydrochloride	9.7E-01 ca	4.1E+00 ca	1.5E-02 ca	1.5E-01 ca
	8.0E-02 l		8.0E-02 r	0	0.10		91-58-7	beta-Chloronaphthalene	5.2E+03 nc	5.5E+04 nc	2.9E+02 nc	2.9E+03 nc
2.5E-02 h		2.5E-02 r	r	0	0.10		88-73-3	o-Chloronitrobenzene	1.6E+01 ca	7.6E+01 ca	2.7E-01 ca	2.7E+00 ca
1.8E-02 h		1.8E-02 r	r	0	0.10		100-00-5	p-Chloronitrobenzene	2.5E+01 ca	1.1E+02 ca	3.7E-01 ca	3.7E+00 ca
	5.0E-03 l		5.0E-03 r	0	0.10		95-57-8	2-Chlorophenol	3.3E+02 nc	3.4E+03 nc	1.6E+01 nc	1.6E+02 nc
	2.9E-02 r		2.9E-02 h	1	0.10	9.7E+03	75-29-6	2-Chloropropane	3.5E+02 nc	1.3E+03 nc	1.0E+02 nc	1.7E+02 nc
1.1E-02 h	1.5E-02 l	1.1E-02 r	1.5E-02 r	0	0.10		1897-45-6	Chlorothalonil	4.0E+01 ca**	1.7E+02 ca*	8.1E-01 ca*	8.1E+00 ca*
	2.0E-02 l		2.0E-02 r	1	0.10	1.5E+04	95-49-8	o-Chlorotoluene	3.4E+02 nc	1.4E+03 nc	7.3E+01 nc	1.2E+02 nc
	2.0E-01 l		2.0E-01 r	0	0.10		101-21-3	Chlorpropham	1.3E+04 nc	1.0E+05 max	7.3E+02 nc	7.3E+03 nc
	3.0E-03 l		3.0E-03 r	0	0.10		2921-88-2	Chlorpyrifos	2.0E+02 nc	2.0E+03 nc	1.1E+01 nc	1.1E+02 nc
	1.0E-02 h		1.0E-02 r	0	0.10		5598-13-0	Chlorpyrifos-methyl	6.5E+02 nc	6.8E+03 nc	3.7E+01 nc	3.7E+02 nc
	5.0E-02 l		5.0E-02 r	0	0.10		64902-72-3	Chlorsulfuron	3.3E+03 nc	3.4E+04 nc	1.8E+02 nc	1.8E+03 nc
	8.0E-04 h		8.0E-04 r	0	0.10		602-36-56-4	Chlorthiophos	5.2E+01 nc	5.5E+02 nc	2.9E+00 nc	2.9E+01 nc
		4.2E+01 l		0	0.01		n/a	Total Chromium (1/6 ratio Cr VI/Cr III)	2.1E+02 ca	4.5E+02 ca	1.6E-04 ca	
	5.0E-03 l	2.9E+02 l		0	0.01		7440-47-3	Chromium VI	3.0E+01 ca	6.4E+01 ca	2.3E-05 ca	1.6E+02 nc
								CAL-Modified PRG (PEA, 1994)	2.0E-01			1.6E-01
	6.0E-02 e		2.9E-04 e	0	0.01		7440-48-4	Cobalt	4.6E+03 nc	9.7E+04 nc	1.0E+00 nc	2.2E+03 nc
		2.2E+00 l		0	0.01		8007-45-2	Coke Oven Emissions			3.1E-03 ca	

	3.7E-02 h			0	0.01		7440-50-8	Copper and compounds	2.8E+03 nc	6.3E+04 nc		1.4E+03 nc
1.9E+00 h	1.0E-02 x	1.9E+00 x	1.0E-02 r	1	0.10	3.5E+03	123-73-9	Crotonaldehyde	1.2E-02 ca	2.6E-02 ca	3.5E-03 ca	5.9E-03 ca
	4.0E-02 I		2.6E-03 h	1	0.10	1.2E+04	98-82-8	Cumene	4.9E+01 nc	1.6E+02 nc	9.4E+00 nc	1.9E+01 nc
8.4E-01 h	2.0E-03 h	8.4E-01 r	2.0E-03 r	0	0.10		21725-46-2	Cyanazine	5.3E-01 ca*	2.3E+00 ca	8.0E-03 ca	8.0E-02 ca
					0.01		n/a	Cyanides				
	1.0E-01 h			0	0.01		542-62-1	Barium cyanide	7.7E+03 nc	1.0E+05 max		3.7E+03 nc
	5.0E-03 I			0	0.01		544-92-3	Copper cyanide	3.8E+02 nc	8.5E+03 nc		1.8E+02 nc
	4.0E-02 I			0	0.01		592-01-8	Calcium cyanide	3.1E+03 nc	6.6E+04 nc		1.5E+03 nc
	4.0E-02 I			0	0.10		460-19-5	Cyanogen	2.8E+03 nc	2.7E+04 nc		1.5E+03 nc
	9.0E-02 I			0	0.10		506-68-3	Cyanogen bromide	6.9E+03 nc	1.0E+05 max		3.3E+03 nc
	5.0E-02 I			0	0.10		506-77-4	Cyanogen chloride	3.3E+03 nc	3.4E+04 nc		1.8E+03 nc
	2.0E-02 I			0	0.10		57-12-5	Free cyanide	1.3E+03 nc	1.4E+04 nc		7.3E+02 nc
	2.0E-02 I		6.6E-04 I	1	0.10		74-90-8	Hydrogen cyanide			3.1E+00 nc	6.2E+00 nc
	5.0E-02 I			0	0.10		151-50-8	Potassium cyanide	3.3E+03 nc	3.4E+04 nc		1.8E+03 nc
	2.0E-01 I			0	0.10		506-61-6	Potassium silver cyanide	1.3E+04 nc	1.0E+05 max		7.3E+03 nc
	1.0E-01 I			0	0.10		506-64-9	Silver cyanide	6.5E+03 nc	1.0E+05 max		3.7E+03 nc
	4.0E-02 I			0	0.10		143-33-9	Sodium cyanide	2.8E+03 nc	2.7E+04 nc		1.5E+03 nc
	5.0E-02 I			0	0.10		557-21-1	Zinc cyanide	3.3E+03 nc	3.4E+04 nc		1.8E+03 nc
	5.0E+00 I		5.0E+00 r	0	0.10		108-94-1	Cyclohexanone	1.0E+05 max	1.0E+05 max	1.8E+04 nc	1.8E+05 nc
	2.0E-01 I		2.0E-01 r	0	0.10		108-91-8	Cyclohexylamine	1.3E+04 nc	1.0E+05 max	7.3E+02 nc	7.3E+03 nc
	5.0E-03 I		5.0E-03 r	0	0.10		68085-85-8	Cyhalothrin/Karate	3.3E+02 nc	3.4E+03 nc	1.8E+01 nc	1.8E+02 nc
	1.0E-02 I		1.0E-02 r	0	0.10		52315-07-8	Cypermethrin	6.5E+02 nc	6.6E+03 nc	3.7E+01 nc	3.7E+02 nc
	7.5E-03 I		7.5E-03 r	0	0.10		66215-27-8	Cyromazine	4.9E+02 nc	5.1E+03 nc	2.7E+01 nc	2.7E+02 nc
	1.0[illegible]		1.0E-02 r	0	0.10		1861-32-1	Dacthal	6.5E+02 nc	1.0E+05 max	3.7E+01 nc	3.7E+02 nc
	3.0E[illegible]		3.0E-02 r	0	0.10		75-99-0	Dalapon	2.0E+03 nc	2.0E+04 nc	1.1E+02 nc	1.1E+03 nc
	2.8E-02 I		2.8E-02 r	0	0.10		39515-41-8	Danitol	1.6E+03 nc	1.7E+04 nc	9.1E+01 nc	9.1E+02 nc
2.4E-01 I		2.4E-01 r		0	0.10		72-54-8	DDD	1.9E+00 ca	7.9E+00 ca	2.8E-02 ca	2.8E-01 ca
3.4E-01 I		3.4E-01 r		0	0.10		72-55-9	DDE	1.3E+00 ca	5.6E+00 ca	2.0E-02 ca	2.0E-01 ca
3.4E-01 I	5.0E-04 I	3.4E-01 I	5.0E-04 r	0	0.10		50-29-3	DDT	1.3E+00 ca*	5.6E+00 ca*	2.0E-02 ca*	2.0E-01 ca*
	1.0E-02 I		1.0E-02 r	0	0.10		1163-19-5	Decabromodiphenyl ether	6.5E+02 nc	6.6E+03 nc	3.7E+01 nc	3.7E+02 nc
	4.0E-05 I		4.0E-05 r	0	0.10		8065-48-3	Demeton	2.6E+00 nc	2.7E+01 nc	1.5E-01 nc	1.5E+00 nc
6.1E-02 h		6.1E-02 r		0	0.10		2303-16-4	Diallate	7.3E+00 ca	3.1E+01 ca	1.1E-01 ca	1.1E+00 ca
	9.0E-04 h		9.0E-04 r	0	0.10		333-41-5	Diazinon	5.9E+01 nc	6.1E+02 nc	3.3E+00 nc	3.3E+01 nc
	4.0E-03 e		4.0E-03 r	0	0.10		132-64-9	Dibenzofuran	2.6E+02 nc	2.7E+03 nc	1.5E+01 nc	1.5E+02 nc
	1.0E-02 I		1.0E-02 r	0	0.10		106-37-6	1,4-Dibromobenzene	6.5E+02 nc	6.6E+03 nc	3.7E+01 nc	3.7E+02 nc
6.4E-02 I	2.0E-02 I	6.4E-02 r	2.0E-02 r	0	0.10		124-48-1	Dibromochloromethane	5.3E+00 ca*	2.3E+01 ca	6.0E-02 ca	1.0E+00 ca
1.4E+00 h	5.7E-05 r	2.4E-03 h	5.7E-05 I	0	0.10		96-12-8	1,2-Dibromo-3-chloropropane	3.2E-01 ca**	1.4E+00 ca*	2.1E-01 nc	4.8E-02 ca*
								CAL-Modified PRG (PEA, 1994)	6.0E-02		9.6E-04	4.7E-03
8.5E+01 I	5.7E-05 r	7.7E-01 I	5.7E-05 h	1	0.10	2.0E+04	106-93-4	1,2-Dibromoethane	5.1E-03 ca	2.1E-02 ca	6.7E-03 ca*	7.6E-04 ca
	1.0E-01 I		1.0E-01 r	0	0.10		84-74-2	Dibutyl phthalate	6.5E+03 nc	6.6E+04 nc	3.7E+02 nc	3.7E+03 nc
	3.0E-02 I		3.0E-02 r	0	0.10		1918-00-9	Dicamba	2.0E+03 nc	2.0E+04 nc	1.1E+02 nc	1.1E+03 nc
	9.0E-02 I		5.7E-02 x	1	0.10	4.0E+04	95-50-1	1,2-Dichlorobenzene	2.3E+03 sat	2.3E+03 sat	2.1E+02 nc	3.7E+02 nc
				1	0.10	4.0E+04	541-73-1	1,3-Dichlorobenzene	2.6E+03 sat	2.6E+03 sat		
2.4E-02 h	2.3E-01 r	2.4E-02 r	2.3E-01 I	1	0.10	4.4E+04	106-46-7	1,4-Dichlorobenzene	7.4E+00 ca	2.0E+01 ca	2.6E-01 ca	4.7E-01 ca
4.5E-01 I		4.5E-01 r		0	0.10		91-94-1	3,3-Dichlorobenzidine	9.9E-01 ca	4.2E+00 ca	1.5E-02 ca	1.5E-01 ca
9.3E+00 r		9.3E+00 h		1	0.10	1.3E+04	764-41-0	1,4-Dichloro-2-butene	7.6E-03 ca	1.6E-02 ca	7.2E-04 ca	1.2E-03 ca
	2.0E-01 I		5.7E-02 h	1	0.10	1.3E+03	75-71-8	Dichlorodifluoromethane	1.1E+02 nc	3.7E+02 nc	2.1E+02 nc	3.9E+02 nc
	1.0E-01 h		1.4E-01 h	1	0.10	4.3E+03	75-34-3	1,1-Dichloroethane	8.4E+02 nc	3.0E+03 nc	5.2E+02 nc	6.1E+02 nc
9.1E-02 I		9.1E-02 I		1	0.10	6.6E+03	107-06-2	1,2-Dichloroethane (EDC)	4.4E-01 ca	9.6E-01 ca	7.4E-02 ca	1.2E-01 ca
6.0E-01 I	9.0E-03 I	1.6E-01 I	9.0E-03 r	1	0.10	1.0E+03	75-35-4	1,1-Dichloroethylene	3.6E-02 ca	8.2E-02 ca	3.6E-02 ca	4.6E-02 ca
	1.0E-02 h		1.0E-02 r	1	0.10	4.1E+03	156-59-2	1,2-Dichloroethylene (cis)	5.9E+01 nc	2.0E+02 nc	3.7E+01 nc	6.1E+01 nc
	2.0E-02 I		2.0E-02 r	1	0.10	6.1E+03	156-60-5	1,2-Dichloroethylene (trans)	1.7E+02 nc	6.0E+02 nc	7.3E+01 nc	1.2E+02 nc
	9.0E-03 h		9.0E-03 r	1	0.10	6.1E+03	540-59-0	1,2-Dichloroethylene (mixture)	7.5E+01 nc	2.7E+02 nc	3.3E+01 nc	5.5E+01 nc
	3.0E-03 I		3.0E-03 r	0	0.10		120-83-2	2,4-Dichlorophenol	2.0E+02 nc	2.0E+03 nc	1.1E+01 nc	1.1E+02 nc
	8.0E-03 I		8.0E-03 r	0	0.10		94-82-6	4-(2,4-Dichlorophenoxy)butyric Acid (2,4-DB)	5.2E+02 nc	5.5E+03 nc	2.9E+01 nc	2.9E+02 nc
	1.0E-02 I		1.0E-02 r	0	0.10		94-75-7	2,4-Dichlorophenoxyacetic Acid (2,4-D)	6.5E+02 nc	6.6E+03 nc	3.7E+01 nc	3.7E+02 nc
6.6E-02 h	1.1E-03 r	6.6E-02 r	1.1E-03 I	1	0.10	7.7E+03	78-87-5	1,2-Dichloropropane	6.6E-01 ca*	1.6E+00 ca*	9.9E-02 ca*	1.6E-01 ca*
1.8E-01 h	3.0E-04 I	1.3E-01 h	5.7E-03 I	1	0.10	1.2E+04	542-75-6	1,3-Dichloropropene	5.1E-01 ca*	1.2E+00 ca	5.2E-02 ca	8.1E-02 ca
	3.0E-03 I		3.0E-03 r	0	0.10		616-23-9	2,3-Dichloropropanol	2.0E+02 nc	2.0E+03 nc	1.1E+01 nc	1.1E+02 nc
2.9E-01 I	5.0E-04 I	2.9E-01 r	1.4E-04 I	0	0.10		62-73-7	Dichlorvos	1.5E+00 ca**	6.6E+00 ca*	2.3E-02 ca*	2.3E-01 ca*
4.4E-01 x		4.4E-01 r		0	0.10		115-32-2	Dicofol	1.0E+00 ca	4.3E+00 ca	1.5E-02 ca	1.5E-01 ca
	3.0E-02 h		5.7E-05 h	1	0.10		77-73-6	Dicyclopentadiene			2.1E-01 nc	4.2E-01 nc
1.6E+01 I	5.0E-05 I	1.6E+01 I	5.0E-05 r	0	0.10		60-57-1	Dieldrin	2.8E-02 ca*	1.2E-01 ca	4.2E-04 ca	4.2E-03 ca
	5.7E-03 h		5.7E-03 x	0	0.10		112-34-5	Diethylene glycol, monobutyl ether	3.7E+02 nc	3.9E+03 nc	2.1E+01 nc	2.1E+02 nc
	2.0E+00 h		2.0E+00 r	0	0.10		111-90-0	Diethylene glycol, monoethyl ether	1.0E+05 max	1.0E+05 max	7.3E+03 nc	7.3E+04 nc
	1.1E-02 h		1.1E-02 r	0	0.10		617-84-5	Diethylformamide	7.2E+02 nc	7.5E+03 nc	4.0E+01 nc	4.0E+02 nc
1.2E-03 I	6.0E-01 I	1.2E-03 r	6.0E-01 r	0	0.10		103-23-1	Di(2-ethylhexyl)adipate	3.7E+02 nc	1.6E+03 nc	5.6E+00 nc	5.6E+01 nc
	8.0E-01 I		8.0E-01 r	0	0.10		84-66-2	Diethyl phthalate	5.2E+04 nc	1.0E+05 max	2.9E+03 nc	2.9E+04 nc
4.7E+03 h		4.7E+03 r		0	0.10		56-53-1	Diethylstilbestrol	6.5E-05 ca	4.1E-04 ca	1.4E-06 ca	1.4E-05 ca
	8.0E-02 I		8.0E-02 r	0	0.10		43222-48-6	Difenzoquat (Avenge)	5.2E+03 nc	5.5E+04 nc	2.9E+02 nc	2.9E+03 nc
	2.0E-02 I		2.0E-02 r	0	0.10		35367-38-5	Diflubenzuron	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	1.1E+01 r		1.1E+01 I	1	0.10		75-37-6	1,1-Difluoroethane			4.2E+04 nc	6.9E+04 nc
	8.0E-02 I		8.0E-02 r	0	0.10		1445-75-6	Diisopropyl methylphosphonate	5.2E+03 nc	5.5E+04 nc	2.9E+02 nc	2.9E+03 nc
	2.0E-02 I		2.0E-02 r	0	0.10		55290-64-7	Dimethipin	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	[illegible]E-04 I		2.0E-04 r	0	0.10		60-51-5	Dimethoate	1.3E+01 nc	1.4E+02 nc	7.3E-01 [illegible]	7.3E+00 nc

1.4E-02 h		1.4E-02 r		0	0.10		119-90-4	3,3'-Dimethoxybenzidine	3.2E+01 ca	1.4E+02 ca	4.6E-01 ca	4.6E+00 ca
	5.7E-06 r		5.7E-06 x	1	0.10	8.4E+03	124-40-3	Dimethylamine	6.2E-02 nc	2.3E-01 nc	2.1E-02 nc	3.5E-02 nc
	2.0E-03 I		2.0E-03 r	0	0.10		121-69-7	N-N-Dimethylaniline	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
7.5E-01 h		7.5E-01 r		0	0.10		95-68-1	2,4-Dimethylaniline	5.9E-01 ca	2.5E+00 ca	9.0E-03 ca	9.0E-02 ca
5.8E-01 h		5.8E-01 r		0	0.10		21436-96-4	2,4-Dimethylaniline hydrochloride	7.7E-01 ca	3.3E+00 ca	1.2E-02 ca	1.2E-01 ca
9.2E+00 h		9.2E+00 r		0	0.10		119-93-7	3,3'-Dimethylbenzidine	4.8E-02 ca	2.1E-01 ca	7.3E-04 ca	7.3E-03 ca
2.6E+00 x		3.5E+00 x		0	0.10		57-14-7	1,1-Dimethylhydrazine	1.7E-01 ca	7.3E-01 ca	1.9E-03 ca	2.6E-02 ca
3.7E+01 x		3.7E+01 x		0	0.10		540-73-8	1,2-Dimethylhydrazine	1.2E-02 ca	5.2E-02 ca	1.8E-04 ca	1.8E-03 ca
	1.0E-01 h		6.6E-03 I	0	0.10		68-12-2	N,N-Dimethylformamide	6.5E+03 nc	6.8E+04 nc	3.1E+01 nc	3.7E+03 nc
	2.0E-02 I		2.0E-02 r	0	0.10		105-67-9	2,4-Dimethylphenol	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	6.0E-04 I		6.0E-04 r	0	0.10		576-26-1	2,6-Dimethylphenol	3.9E+01 nc	4.1E+02 nc	2.2E+00 nc	2.2E+01 nc
	1.0E-03 I		1.0E-03 r	0	0.10		95-65-8	3,4-Dimethylphenol	6.5E+01 nc	6.8E+02 nc	3.7E+00 nc	3.7E+01 nc
	1.0E+01 h		1.0E+01 r	0	0.10		131-11-3	Dimethyl phthalate	1.0E+05 max	1.0E+05 max	3.7E+04 nc	3.7E+05 nc
	1.0E-01 I		1.0E-01 r	0	0.10		120-61-6	Dimethyl terephthalate	6.5E+03 nc	6.8E+04 nc	3.7E+02 nc	3.7E+03 nc
	2.0E-03 I		2.0E-03 r	0	0.10		131-89-5	4,6-Dinitro-o-cyclohexyl phenol	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
	1.0E-04 I		1.0E-04 r	0	0.10		99-65-0	1,3-Dinitrobenzene	6.5E+00 nc	6.8E+01 nc	3.7E-01 nc	3.7E+00 nc
	4.0E-04 h		4.0E-04 r	0	0.10		528-29-0	1,2-Dinitrobenzene	2.6E+01 nc	2.7E+02 nc	1.5E+00 nc	1.5E+01 nc
	4.0E-04 h		4.0E-04 r	0	0.10		100-25-4	1,4-Dinitrobenzene	2.6E+01 nc	2.7E+02 nc	1.5E+00 nc	1.5E+01 nc
	2.0E-03 I		2.0E-03 r	0	0.10		51-28-5	2,4-Dinitrophenol	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
6.6E-01 I		6.6E-01 r		0	0.10		25321-14-6	Dinitrotoluene mixture	6.5E-01 ca	2.6E+00 ca	9.9E-03 ca	9.9E-02 ca
	2.0E-03 I		2.0E-03 r	0	0.10		121-14-2	2,4-Dinitrotoluene (also see Dinitrotoluene mixture)	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
	1.0E-03 h		1.0E-03 r	0	0.10		606-20-2	2,6-Dinitrotoluene (also see Dinitrotoluene mixture)	6.5E+01 nc	6.8E+02 nc	3.7E+00 nc	3.7E+01 nc
	1.0E-03 I		1.0E-03 r	0	0.10		88-85-7	Dinoseb	6.5E+01 nc	6.8E+02 nc	3.7E+00 nc	3.7E+01 nc
	2.0E-02 h		2.0E-02 r	0	0.10		117-84-0	di-n-Octyl phthalate	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
1.1E-02 I		1.1E-02 r		1	0.10	3.6E+04	123-91-1	1,4-Dioxane	1.4E+01 ca	3.7E+01 ca	6.1E-01 ca	1.0E+00 ca
	3.0E-02 I		3.0E-02 r	0	0.10		957-51-7	Diphenamid	2.0E+03 nc	2.0E+04 nc	1.1E+02 nc	1.1E+03 nc
	2.5E-02 I		2.5E-02 r	0	0.10		122-39-4	Diphenylamine	1.6E+03 nc	1.7E+04 nc	9.1E+01 nc	9.1E+02 nc
8.0E-01 I		7.7E-01 I		0	0.10		122-66-7	1,2-Diphenylhydrazine	5.6E-01 ca	2.4E+00 ca	8.7E-03 ca	8.4E-02 ca
	2.2E-03 I		2.2E-03 r	0	0.10		85-00-7	Diquat	1.4E+02 nc	1.5E+03 nc	8.0E+00 nc	8.0E+01 nc
8.6E+00 h		8.6E+00 r		0	0.10		1937-37-7	Direct black 38	5.2E-02 ca	2.2E-01 ca	7.8E-04 ca	7.8E-03 ca
8.1E+00 h		8.1E+00 r		0	0.10		2602-46-2	Direct blue 6	5.5E-02 ca	2.4E-01 ca	8.3E-04 ca	8.3E-03 ca
9.3E+00 h		9.3E+00 r		0	0.10		16071-86-6	Direct brown 95	4.8E-02 ca	2.1E-01 ca	7.2E-04 ca	7.2E-03 ca
	4.0E-05 I		4.0E-05 r	0	0.10		298-04-4	Disulfoton	2.6E+00 nc	2.7E+01 nc	1.5E-01 nc	1.5E+00 nc
	1.0E-02 I		1.0E-02 r	0	0.10		505-29-3	1,4-Dithiane	6.5E+02 nc	6.8E+03 nc	3.7E+01 nc	3.7E+02 nc
	2.0E-03 I		2.0E-03 r	0	0.10		330-54-1	Diuron	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
	4.0E-03 I		4.0E-03 r	0	0.10		2439-10-3	Dodine	2.6E+02 nc	2.7E+03 nc	1.5E+01 nc	1.5E+02 nc
	5.0E-05 h		5.0E-05 r	0	0.10		115-29-7	Endosulfan	3.3E+00 nc	3.4E+01 nc	1.8E-01 nc	1.8E+00 nc
	2.0E-02 I		2.0E-02 r	0	0.10		145-73-3	Endothall	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	3.0E-04 I		3.0E-04 r	0	0.10		72-20-8	Endrin	2.0E+01 nc	2.0E+02 nc	1.1E+00 nc	1.1E+01 nc
9.9E-03 I	2.0E-03 h	4.2E-03 I	2.9E-04 I	1	0.10	2.1E+04	106-89-8	Epichlorohydrin	8.6E+00 nc	3.0E+01 nc	1.0E+00 nc	2.0E+00 nc
	5.7E-03 r		5.7E-03 I	0	0.10		106-88-7	1,2-Epoxybutane	3.7E+02 nc	3.9E+03 nc	2.1E+01 nc	2.1E+02 nc
	2.5E-02 I		2.5E-02 r	0	0.10		759-94-4	EPTC (S-Ethyl dipropylthiocarbamate)	1.6E+03 nc	1.7E+04 nc	9.1E+01 nc	9.1E+02 nc
	5.0E-03 I		5.0E-03 r	0	0.10		16672-87-0	Ethephon (2-chloroethyl phosphonic acid)	3.3E+02 nc	3.4E+03 nc	1.8E+01 nc	1.8E+02 nc
	5.0E-04 I		5.0E-04 r	0	0.10		563-12-2	Ethion	3.3E+01 nc	3.4E+02 nc	1.8E+00 nc	1.8E+01 nc
	4.0E-01 h		5.7E-02 I	0	0.10		110-80-5	2-Ethoxyethanol	2.6E+04 nc	1.0E+05 max	2.1E+02 nc	1.5E+04 nc
	3.0E-01 h		3.0E-01 r	0	0.10		111-15-9	2-Ethoxyethanol acetate	2.0E+04 nc	1.0E+05 max	1.1E+03 nc	1.1E+04 nc
	9.0E-01 I		9.0E-01 r	0	0.10		141-78-6	Ethyl acetate	5.9E+04 nc	1.0E+05 max	3.3E+03 nc	3.3E+04 nc
4.6E-02 h		4.6E-02 r		1	0.10	3.5E+03	140-88-5	Ethyl acrylate	4.6E-01 ca	1.0E+00 ca	1.4E-01 ca	2.3E-01 ca
	1.0E-01 I		2.9E-01 I	1	0.10	1.1E+04	100-41-4	Ethylbenzene	8.9E+02 sat	8.9E+02 sat	1.1E+03 nc	1.3E+03 nc
	3.0E-01 h		3.0E-01 r	0	0.10		109-78-4	Ethylene cyanohydrin	2.0E+04 nc	1.0E+05 max	1.1E+03 nc	1.1E+04 nc
	2.0E-02 h		2.0E-02 r	0	0.10		107-15-3	Ethylene diamine	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	2.0E+00 I		2.0E+00 r	0	0.10		107-21-1	Ethylene glycol	1.3E+05 nc	1.0E+05 max	7.3E+03 nc	7.3E+04 nc
	5.7E-03 r		5.7E-03 h	0	0.10		111-76-2	Ethylene glycol, monobutyl ether	3.7E+02 nc	3.9E+03 nc	2.1E+01 nc	2.1E+02 nc
1.0E+00 h		3.5E-01 h		1	0.10	8.9E+03	75-21-8	Ethylene oxide	1.2E-01 ca	3.0E-01 ca	1.9E-02 ca	2.4E-02 ca
8.0E-01 h	8.0E-05 I	8.0E-01 r	8.0E-06 r	0	0.10		96-45-7	Ethylene thiourea (ETU)	7.4E-01 ca**	3.2E+00 ca*	1.1E-02 ca*	1.1E-01 ca*
	2.0E-02 e		2.9E+00 I	1	0.10	1.9E+03	75-00-3	Ethyl chloride	1.1E+03 nc	2.7E+03 sat	1.0E+04 nc	7.1E+02 nc
	2.0E-01 I		2.0E-01 r	1	0.10	7.3E+04	60-29-7	Ethyl ether	3.6E+03 sat	3.6E+03 sat	7.3E+02 nc	1.2E+03 nc
	9.0E-02 h		9.0E-02 r	1	0.10	3.5E+03	97-63-2	Ethyl methacrylate	3.6E+02 sat	3.6E+02 sat	3.3E+02 nc	5.5E+02 nc
	1.0E-05 I		1.0E-05 r	0	0.10		2104-64-5	Ethyl p-nitrophenyl phenylphosphorothioate	6.5E-01 nc	6.8E+00 nc	3.7E-02 nc	3.7E-01 nc
	3.0E+00 I		3.0E+00 r	0	0.10		84-72-0	Ethylphthalyl ethyl glycolate	1.0E+05 max	1.0E+05 max	1.1E+04 nc	1.1E+05 nc
	8.0E-03 I		8.0E-03 r	0	0.10		101200-48-0	Express	5.2E+02 nc	5.5E+03 nc	2.9E+01 nc	2.9E+02 nc
	2.5E-04 I		2.5E-04 r	0	0.10		22224-92-6	Fenamiphos	1.6E+01 nc	1.7E+02 nc	9.1E-01 nc	9.1E+00 nc
	1.3E-02 I		1.3E-02 r	0	0.10		2164-17-2	Fluometuron	6.5E+02 nc	6.8E+03 nc	4.7E+01 nc	4.7E+02 nc
	6.0E-02 I		6.0E-02 r	0	0.10		7782-41-4	Fluoride	3.9E+03 nc	4.1E+04 nc	2.2E+02 nc	2.2E+03 nc
	8.0E-02 I		8.0E-02 r	0	0.10		59756-60-4	Fluoridone	5.2E+03 nc	5.5E+04 nc	2.9E+02 nc	2.9E+03 nc
	2.0E-02 I		2.0E-02 r	0	0.10		56425-91-3	Fluprimidol	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	6.0E-02 I		6.0E-02 r	0	0.10		66332-96-5	Flutolanil	3.9E+03 nc	4.1E+04 nc	2.2E+02 nc	2.2E+03 nc
	1.0E-02 I		1.0E-02 r	0	0.10		69409-94-5	Fluvalinate	6.5E+02 nc	6.8E+03 nc	3.7E+01 nc	3.7E+02 nc
3.5E-03 I	1.0E-01 I	3.5E-03 r	1.0E-01 r	0	0.10		133-07-3	Folpet	1.3E+02 ca*	5.5E+02 ca	1.9E+00 ca	1.9E+01 ca
1.9E-01 I		1.9E-01 r		0	0.10		72178-02-0	Fomesafen	2.3E+00 ca	1.0E+01 ca	3.5E-02 ca	3.5E-01 ca
	2.0E-03 I		2.0E-03 r	0	0.10		944-22-9	Fonofos	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
	1.5E-01 I	4.6E-02 I		0	0.10		50-00-0	Formaldehyde	9.8E+03 nc	1.0E+05 nc	1.5E-01 ca	5.5E+03 nc
	2.0E+00 h		2.0E+00 r	0	0.10		64-18-6	Formic Acid	1.0E+05 max	1.0E+05 max	7.3E+03 nc	7.3E+04 nc
	3.0E+00 I		3.0E+00 r	0	0.10		39148-24-8	Fosetyl-al	1.0E+05 max	1.0E+05 max	1.1E+04 nc	1.1E+05 nc
	1.0E-03 I		1.0E-03 r	0	0.10		110-00-9	Furan	6.5E+01 nc	6.8E+02 nc	3.7E+00 nc	3.7E+01 nc

3.6E+00 h		3.6E+00 r		0	0.10		67-45-8	Furazolidone	1.2E-01 ca	5.0E-01 ca	1.6E-03 ca	1.6E-02 ca
	3.0E-03 l		1.4E-02 h	0	0.10		98-01-1	Furfural	2.0E+02 nc	2.0E+03 nc	5.2E+01 nc	1.1E+02 nc
5.0E+01 h		5.0E+01 r		0	0.10		531-82-8	Furium	6.6E-03 ca	3.8E-02 ca	1.3E-04 ca	1.3E-03 ca
3.0E-02 l		3.0E-02 r		0	0.10		60568-05-0	Furmecyclox	1.5E+01 ca	6.4E+01 ca	2.2E-01 ca	2.2E+00 ca
	4.0E-04 l		4.0E-04 r	0	0.10		77182-82-2	Glufosinate-ammonium	2.6E+01 nc	2.7E+02 nc	1.5E+00 nc	1.5E+01 nc
	4.0E-04 l		2.9E-04 h	0	0.10		765-34-4	Glycidaldehyde	2.6E+01 nc	2.7E+02 nc	1.0E+00 nc	1.5E+01 nc
	1.0E-01 l		1.0E-01 r	0	0.10		1071-83-6	Glyphosate	6.5E+03 nc	6.6E+04 nc	3.7E+02 nc	3.7E+03 nc
	5.0E-05 l		5.0E-05 r	0	0.10		69806-40-2	Haloxyfop-methyl	3.3E+00 nc	3.4E+01 nc	1.8E-01 nc	1.8E+00 nc
	1.3E-02 l		1.3E-02 r	0	0.10		79277-27-3	Harmony	6.5E+02 nc	6.6E+03 nc	4.7E+01 nc	4.7E+02 nc
4.5E+00 l	5.0E-04 l	4.6E+00 l	5.0E-04 r	0	0.10		76-44-8	Heptachlor	9.9E-02 ca	4.2E-01 ca	1.5E-03 ca	1.5E-02 ca
9.1E+00 l	1.3E-05 l	9.1E+00 l	1.3E-05 r	0	0.10		1024-57-3	Heptachlor epoxide	4.9E-02 ca**	2.1E-01 ca*	7.4E-04 ca*	7.4E-03 ca*
	2.0E-03 l		2.0E-03 r	0	0.10		87-82-1	Hexabromobenzene	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
1.6E+00 l	8.0E-04 l	1.6E+00 l	8.0E-04 r	0	0.10		118-74-1	Hexachlorobenzene	2.8E-01 ca*	1.2E+00 ca	4.2E-03 ca	4.2E-02 ca
7.8E-02 l	2.0E-04 h	7.7E-02 l	2.0E-04 r	0	0.10		87-68-3	Hexachlorobutadiene	5.7E+00 ca**	2.4E+01 ca*	8.7E-02 ca*	8.6E-01 ca*
6.3E+00 l		6.3E+00 l		0	0.10		319-84-6	HCH (alpha)	7.1E-02 ca	3.0E-01 ca	1.1E-03 ca	1.1E-02 ca
1.6E+00 l		1.6E+00 l		0	0.10		319-85-7	HCH (beta)	2.5E-01 ca	1.1E+00 ca	3.7E-03 ca	3.7E-02 ca
1.3E+00 h	3.0E-04 l	1.3E+00 r	3.0E-04 r	0	0.10		58-89-9	HCH (gamma) Lindane	3.4E-01 ca*	1.5E+00 ca	5.2E-03 ca	5.2E-02 ca
1.6E+00 l		1.6E+00 l		0	0.10		58-89-9	HCH-technical	2.5E-01 ca	1.1E+00 ca	3.8E-03 ca	3.7E-02 ca
	7.0E-03 l		2.0E-05 h	0	0.10		77-47-4	Hexachlorocyclopentadiene	4.5E+02 nc	4.6E+03 nc	7.3E-02 nc	2.6E+02 nc
6.2E+03 l		4.6E+03 l		0	0.10		19408-74-3	Hexachlorodibenzo-p-dioxin mixture (HxCDD)	7.2E-05 ca	3.1E-04 ca	1.5E-06 ca	1.1E-05 ca
1.4E-02 l	1.0E-03 l	1.4E-02 l	1.0E-03 r	0	0.10		67-72-1	Hexachloroethane	3.2E+01 ca**	1.4E+02 ca**	4.8E-01 ca**	4.8E+00 ca**
	3.0E-04 l		3.0E-04 r	0	0.10		70-30-4	Hexachlorophene	2.0E+01 nc	2.0E+02 nc	1.1E+00 nc	1.1E+01 nc
1.1E-01 l	3.0E-03 l	1.1E-01 r	3.0E-03 r	0	0.10		121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine	4.0E+00 ca*	1.7E+01 ca	6.1E-02 ca	6.1E-01 ca
	2.9E-06 r		2.9E-06 l	0	0.10		822-06-0	1,6-Hexamethylene diisocyanate			1.0E-02 nc	1.0E-01 nc
	6.0E-02 h		5.7E-02 l	1	0.10	3.5E+03	110-54-3	n-Hexane	2.9E+02 nc	3.4E+02 sat	2.1E+02 nc	3.5E+02 nc
	3.3E-02 l		3.3E-02 r	0	0.10		51235-04-2	Hexazinone	2.2E+03 nc	2.2E+04 nc	1.2E+02 nc	1.2E+03 nc
3.0E+00 l		1.7E+01 l		0	0.10		302-01-2	Hydrazine, hydrazine sulfate	1.5E-01 ca	6.4E-01 ca	3.9E-04 ca	2.2E-02 ca
			1.0E-02 l	0	0.10		7647-01-0	Hydrogen chloride			3.7E+01 nc	
	3.0E-03 l		2.9E-04 l	1	0.10		7783-06-4	Hydrogen sulfide			1.0E+00 nc	2.0E+00 nc
	4.0E-02 h		4.0E-02 r	0	0.10		123-31-9	p-Hydroquinone	2.6E+03 nc	2.7E+04 nc	1.5E+02 nc	1.5E+03 nc
	1.3E-02 l		1.3E-02 r	0	0.10		35554-44-0	Imazalil	8.5E+02 nc	8.9E+03 nc	4.7E+01 nc	4.7E+02 nc
	2.5E-01 l		2.5E-01 r	0	0.10		81335-37-7	Imazaquin	1.6E+04 nc	1.0E+05 max	9.1E+02 nc	9.1E+03 nc
	4.0E-02 l		4.0E-02 r	0	0.10		36734-19-7	Iprodione	2.6E+03 nc	2.7E+04 nc	1.5E+02 nc	1.5E+03 nc
	3.0E-01 l		3.0E-01 r	0	0.10		78-83-1	Isobutanol	2.0E+04 nc	1.0E+05 max	1.1E+03 nc	1.1E+04 nc
9.5E-04 l	2.0E-01 l	9.5E-04 r	2.0E-01 r	0	0.10		78-59-1	Isophorone	4.7E+02 ca*	2.0E+03 ca*	7.1E+00 ca	7.1E+01 ca
	1.5E-02 l		1.5E-02 r	0	0.10		33820-53-0	Isopropalin	9.8E+02 nc	1.0E+04 nc	5.5E+01 nc	5.5E+02 nc
	1.0E-01 l		1.1E-01 r	0	0.10		1832-54-8	Isopropyl methyl phosphonic acid	6.5E+03 nc	6.6E+04 nc	4.0E+02 nc	3.7E+03 nc
	5.0E-02 l		5.0E-02 r	0	0.10		82558-50-7	Isoxaben	3.3E+03 nc	3.4E+04 nc	1.8E+02 nc	1.8E+03 nc
1.8E+01 e		1.8E+01 r		0	0.10		143-50-0	Kepone	2.5E-02 ca	1.1E-01 ca	3.7E-04 ca	3.7E-03 ca
	2.0E-03 l		2.0E-03 r	0	0.10		77501-63-4	Lactofen	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
Residential PRG Based on Uptake Biokinetic Model				0	NA		7439-92-1	Lead	4.0E+02 nc	1.0E+03 nc		4.0E+00 nc
								"CAL-Modified PRG" (PEA, 1994)	1.3E+02			
	1.0E-07 l			0	0.10		78-00-2	Lead (tetraethyl)	6.5E-03 nc	6.6E-02 nc		3.7E-03 nc
	2.0E-03 l		2.0E-03 r	0	0.10		330-55-2	Linuron	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
	2.0E-02 e			0	0.01		7439-93-2	Lithium	1.5E+03 nc	3.4E+04 nc		7.3E+02 nc
	2.0E-01 l		2.0E-01 r	0	0.10		83055-99-6	Londax	1.3E+04 nc	1.0E+05 max	7.3E+02 nc	7.3E+03 nc
	2.0E-02 l		2.0E-02 r	0	0.10		121-75-5	Malathion	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	1.0E-01 l		1.0E-01 r	0	0.10		108-31-6	Maleic anhydride	6.5E+03 nc	6.6E+04 nc	3.7E+02 nc	3.7E+03 nc
	5.0E-01 l		5.0E-01 r	0	0.10		123-33-1	Maleic hydrazide	3.3E+04 nc	1.0E+05 max	1.8E+03 nc	1.8E+04 nc
	2.0E-05 h		2.0E-05 r	0	0.10		109-77-3	Malononitrile	1.3E+00 nc	1.4E+01 nc	7.3E-02 nc	7.3E-01 nc
	3.0E-02 h		3.0E-02 r	0	0.10		8018-01-7	Mancozeb	2.0E+03 nc	2.0E+04 nc	1.1E+02 nc	1.1E+03 nc
	5.0E-03 l		5.0E-03 r	0	0.10		12427-38-2	Maneb	3.3E+02 nc	3.4E+03 nc	1.8E+01 nc	1.8E+02 nc
	5.0E-03 l		1.4E-05 l	0	0.01		7439-96-5	Manganese and compounds	3.6E+02 nc	7.6E+03 nc	5.1E-02 nc	1.8E+02 nc
	9.0E-05 h		9.0E-05 r	0	0.10		950-10-7	Mephosfolan	5.9E+00 nc	6.1E+01 nc	3.3E-01 nc	3.3E+00 nc
	3.0E-02 l		3.0E-02 r	0	0.10		24307-26-4	Mepiquat	2.0E+03 nc	2.0E+04 nc	1.1E+02 nc	1.1E+03 nc
	3.0E-04 l			0	0.01		7439-97-6	Mercuric chloride	2.3E+01 nc	5.1E+02 nc		1.1E+01 nc
			8.6E-05 l	0	NA		7439-97-6	Mercury (elemental)			3.1E-01 nc	
	1.0E-04 l			0	0.10		22967-92-6	Mercury (methyl)	6.5E+00 nc	6.6E+01 nc		3.7E+00 nc
	3.0E-05 l		3.0E-05 r	0	0.10		150-50-5	Merphos	2.0E+00 nc	2.0E+01 nc	1.1E-01 nc	1.1E+00 nc
	3.0E-05 l		3.0E-05 r	0	0.10		78-48-8	Merphos oxide	2.0E+00 nc	2.0E+01 nc	1.1E-01 nc	1.1E+00 nc
	6.0E-02 l		6.0E-02 r	0	0.10		57837-19-1	Metalaxyl	3.9E+03 nc	4.1E+04 nc	2.2E+02 nc	2.2E+03 nc
	1.0E-04 l		2.0E-04 h	1	0.10	5.4E+03	126-98-7	Methacrylonitrile	1.3E+00 nc	5.1E+00 nc	7.3E-01 nc	1.0E+00 nc
	5.0E-05 l		5.0E-05 r	0	0.10		10265-92-6	Methamidophos	3.3E+00 nc	3.4E+01 nc	1.8E-01 nc	1.8E+00 nc
	5.0E-01 l		5.0E-01 r	0	0.10		67-56-1	Methanol	3.3E+04 nc	1.0E+05 max	1.8E+03 nc	1.8E+04 nc
	1.0E-03 l		1.0E-03 r	0	0.10		950-37-8	Methidathion	6.5E+01 nc	6.6E+02 nc	3.7E+00 nc	3.7E+01 nc
	2.5E-02 l		2.5E-02 r	0	0.10		16752-77-5	Methomyl	1.6E+03 nc	1.7E+04 nc	9.1E+01 nc	9.1E+02 nc
	5.0E-03 l		5.0E-03 r	0	0.10		72-43-5	Methoxychlor	3.3E+02 nc	3.4E+03 nc	1.8E+01 nc	1.8E+02 nc
	1.0E-03 h		5.7E-03 l	0	0.10		109-86-4	2-Methoxyethanol	6.5E+01 nc	6.6E+02 nc	2.1E+01 nc	3.7E+01 nc
	2.0E-03 h		2.0E-03 r	0	0.10		110-49-6	2-Methoxyethanol acetate	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
4.6E-02 h		4.6E-02 r		0	0.10		99-59-2	2-Methoxy-5-nitroaniline	9.7E+00 ca	4.1E+01 ca	1.5E-01 ca	1.5E+00 ca
	1.0E+00 h		1.0E+00 r	1	0.10	1.9E+04	79-20-9	Methyl acetate	2.0E+04 nc	8.4E+04 nc	3.7E+03 nc	6.1E+03 nc
	3.0E-02 h		3.0E-02 r	1	0.10	3.5E+03	96-33-3	Methyl acrylate	1.5E+02 nc	5.2E+02 nc	1.1E+02 nc	1.8E+02 nc
2.4E-01 h		2.4E-01 r		0	0.10		100-61-8	2-Methylaniline (o-toluidine)	1.9E+00 ca	7.9E+00 ca	2.8E-02 ca	2.8E-01 ca
1.8E-01 h		1.8E-01 r		0	0.10		636-21-5	2-Methylaniline hydrochloride	2.5E+00 ca	1.1E+01 ca	3.7E-02 ca	3.7E-01 ca
	E+00 x		1.0E+00 r	0	0.10		79-22-1	Methyl chlorocarbonate	6.5E+04 nc	1.0E+05 max	3.7E+03 nc	3.7E+04 nc

	5.0E-04 I		5.0E-04 r	0	0.10	94-74-6	2-Methyl-4-chlorophenoxyacetic acid	3.3E+01 nc	3.4E+02 nc	1.8E+00 nc	1.8E+01 nc
	1.0E-02 I		1.0E-02 r	0	0.10	94-81-5	4-(2-Methyl-4-chlorophenoxy) butyric acid	6.5E+02 nc	6.8E+03 nc	3.7E+01 nc	3.7E+02 nc
	1.0E-03 I		1.0E-03 r	0	0.10	93-65-2	2-(2-Methyl-4-chlorophenoxy) propionic acid	6.5E+01 nc	6.8E+02 nc	3.7E+00 nc	3.7E+01 nc
	1.0E-03 I		1.0E-03 r	0	0.10	16484-77-8	2-(2-Methyl-1,4-chlorophenoxy) propionic acid	6.5E+01 nc	6.8E+02 nc	3.7E+00 nc	3.7E+01 nc
	6.6E-01 r		6.6E-01 h	0	0.10	108-87-2	Methylcyclohexane	5.6E+04 nc	1.0E+05 max	3.1E+03 nc	3.1E+04 nc
	5.7E-06 r		5.7E-06 h	0	0.10	101-68-8	4,4'-Methylenediphenyl isocyanate	3.7E-01 nc	3.9E+00 nc	2.1E-02 nc	2.1E-01 nc
2.5E-01 h		2.5E-01 r		0	0.10	101-77-9	4,4'-Methylenebisbenzeneamine	1.6E+00 ca	7.6E+00 ca	2.7E-02 ca	2.7E-01 ca
1.3E-01 h	7.0E-04 h	1.3E-01 h	7.0E-04 r	0	0.10	101-14-4	4,4'-Methylene bis(2-chloroaniline)	3.4E+00 ca*	1.5E+01 ca*	5.2E-02 ca*	5.2E-01 ca*
4.6E-02 I		4.6E-02 r		0	0.10	101-61-1	4,4'-Methylene bis(N,N'-dimethyl)aniline	9.7E+00 ca	4.1E+01 ca	1.5E-01 ca	1.5E+00 ca
	1.0E-02 h		1.0E-02 r	0	0.10	74-95-3	Methylene bromide	6.5E+02 nc	6.8E+03 nc	3.7E+01 nc	3.7E+02 nc
7.5E-03 I	6.0E-02 I	1.6E-03 I	6.6E-01 h	1	0.10	3.3E+03 75-09-2	Methylene chloride	1.1E+01 ca	2.5E+01 ca	4.1E+00 ca	4.3E+00 ca
			5.7E-06 I	0	NA	101-68-8	4,4'-Methylenediphenyl isocyanate			2.1E-02 ca	
	6.0E-01 I		2.9E-01 I	1	0.10	2.5E+04 78-93-3	Methyl ethyl ketone	6.7E+03 nc	3.4E+04 nc	1.0E+03 nc	1.9E+03 nc
1.1E+00 h		1.1E+00 r		0	0.10	60-34-4	Methyl hydrazine	4.0E-01 ca	1.7E+00 ca	6.1E-03 ca	6.1E-02 ca
	8.0E-02 h		2.3E-02 h	0	0.10	108-10-1	Methyl isobutyl ketone	5.2E+03 nc	5.4E+04 nc	6.3E+01 nc	2.9E+03 nc
	6.0E-02 h		6.0E-02 r	0	0.10	80-62-6	Methyl methacrylate	5.2E+03 nc	5.5E+04 nc	2.9E+02 nc	2.9E+03 nc
3.3E-02 h		3.3E-02 r		0	0.10	99-55-8	2-Methyl-5-nitroaniline	1.3E+01 ca	5.6E+01 ca	2.0E-01 ca	2.0E+00 ca
	2.5E-04 I		2.5E-04 r	0	0.10	298-00-0	Methyl parathion	1.6E+01 nc	1.7E+02 nc	9.1E-01 nc	9.1E+00 nc
	5.0E-02 x		5.0E-02 r	0	0.10	95-48-7	2-Methylphenol	3.3E+03 nc	3.4E+04 nc	1.8E+02 nc	1.8E+03 nc
	5.0E-02 x		5.0E-02 r	0	0.10	108-39-4	3-Methylphenol	3.3E+03 nc	3.4E+04 nc	1.8E+02 nc	1.8E+03 nc
	5.0E-03 h		5.0E-03 r	0	0.10	106-44-5	4-Methylphenol	3.3E+02 nc	3.4E+03 nc	1.8E+01 nc	1.8E+02 nc
	6.0E-03 h		1.1E-02 h	1	0.10	2.7E+04 25013-15-4	Methyl styrene (mixture)	2.2E+02 nc	1.2E+03 nc	4.2E+01 nc	6.0E+01 nc
	7.0E-02 h		7.0E-02 r	1	0.10	2.7E+04 98-83-9	Methyl styrene (alpha)	1.6E+03 nc	8.1E+03 nc	2.6E+02 nc	4.3E+02 nc
	5.0E-03 e		6.6E-01 I	0	0.10	1634-04-4	Methyl tertbutyl ether (MTBE)	3.3E+02 nc	3.4E+03 nc	3.1E+03 nc	1.8E+02 nc
	1.5E-01 I		1.5E-01 r	0	0.10	51218-45-2	Metolachlor (Dual)	6.6E+03 nc	1.0E+05 max	5.5E+02 nc	5.5E+03 nc
	2.5E-02 I		2.5E-02 r	0	0.10	21087-64-9	Metribuzin	1.6E+03 nc	1.7E+04 nc	9.1E+01 nc	9.1E+02 nc
1.6E+00 h	2.0E-04 I	1.6E+00 r	2.0E-04 r	0	0.10	2385-85-5	Mirex	2.5E-01 ca*	1.1E+00 ca	3.7E-03 ca	3.7E-02 ca
	2.0E-03 I		2.0E-03 r	0	0.10	2212-67-1	Molinate	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
	5.0E-03 h			0	0.01	7439-98-7	Molybdenum	3.6E+02 nc	8.5E+03 nc		1.6E+02 nc
	1.0E-01 h		1.0E-01 h	0	0.10	10599-90-3	Monochloramine	6.5E+03 nc	6.6E+04 nc	3.7E+02 nc	3.7E+03 nc
	2.0E-03 I		2.0E-03 r	0	0.10	300-76-5	Naled	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
	1.0E-01 I		1.0E-01 r	0	0.10	15299-99-7	Napropamide	6.5E+03 nc	6.6E+04 nc	3.7E+02 nc	3.7E+03 nc
	2.0E-02 I			0	0.01	7440-02-0	Nickel (soluble salts)	1.5E+03 nc	3.4E+04 nc		7.3E+02 nc
							CAL-Modified PRG (PEA, 1994)	1.5E+02			
		8.4E-01 I		0	0.01	n/a	Nickel refinery dust			8.0E-03 ca	
		1.7E+00 I		0	0.01	12035-72-2	Nickel subsulfide		1.1E+04 ca	4.0E-03 ca	
	1.5E-03 x		1.5E-03 r	0	0.10	1929-82-4	Nitrapyrin	9.6E+01 nc	1.0E+03 nc	5.5E+00 nc	5.5E+01 nc
	1.6E+00 I			0	0.10	14797-55-8	Nitrate	1.0E+05 max	1.0E+05 max		5.6E+04 nc
	1.0E-01 x			0	0.10	10102-43-9	Nitric Oxide	6.5E+03 nc	1.0E+05 max		3.7E+03 nc
	1.0E-01 I			0	0.10	14797-65-0	Nitrite	6.5E+03 nc	1.0E+05 max		3.7E+03 nc
	6.0E-05 r		5.7E-05 h	0	0.10	88-74-4	2-Nitroaniline	3.9E+00 nc	4.1E+01 nc	2.1E-01 nc	2.2E+00 nc
				0	0.10	99-09-2	3-Nitroaniline				
				0	0.10	100-01-6	4-Nitroaniline				
	5.0E-04 I		5.7E-04 h	0	0.10	98-95-3	Nitrobenzene	3.3E+01 nc	3.4E+02 nc	2.1E+00 nc	1.8E+01 nc
	7.0E-02 h		7.0E-02 r	0	0.10	67-20-9	Nitrofurantoin	4.6E+03 nc	4.8E+04 nc	2.6E+02 nc	2.6E+03 nc
1.5E+00 h		9.4E+00 h		0	0.10	59-87-0	Nitrofurazone	3.0E-01 ca	1.3E+00 ca	7.2E-04 ca	4.5E-02 ca
	1.0E+00 x			0	0.10	101102-44-0	Nitrogen dioxide				
	1.0E-01 I		1.0E-01 r	0	0.10	556-88-7	Nitroguanidine	6.5E+03 nc	6.6E+04 nc	3.7E+02 nc	3.7E+03 nc
				0	0.10	100-02-7	4-Nitrophenol				
9.4E+00 r	5.7E-03 r	9.4E+00 h	5.7E-03 I	1	0.10	79-46-9	2-Nitropropane			7.2E-04 ca	3.5E+01 ca
5.4E+00 I		5.6E+00 I		0	0.10	924-16-3	N-Nitrosodi-n-butylamine	6.2E-02 ca	3.5E-01 ca	1.2E-03 ca	1.2E-02 ca
2.6E+00 I		2.6E+00 r		0	0.10	1116-54-7	N-Nitrosodiethanolamine	1.6E-01 ca	6.6E-01 ca	2.4E-03 ca	2.4E-02 ca
1.5E+02 I		1.5E+02 I		0	0.10	55-18-5	N-Nitrosodiethylamine	3.0E-03 ca	1.3E-02 ca	4.5E-05 ca	4.5E-04 ca
5.1E+01 I		4.9E+01 I		0	0.10	62-75-9	N-Nitrosodimethylamine	6.7E-03 ca	3.7E-02 ca	1.4E-04 ca	1.3E-03 ca
4.9E-03 I		4.9E-03 r		0	0.10	86-30-6	N-Nitrosodiphenylamine	9.1E+01 ca	3.9E+02 ca	1.4E+00 ca	1.4E+01 ca
7.0E+00 I		7.0E+00 r		0	0.10	621-64-7	N-Nitroso di-n-propylamine	6.3E-02 ca	2.7E-01 ca	9.6E-04 ca	9.6E-03 ca
2.2E+01 I		2.2E+01 r		0	0.10	10595-95-6	N-Nitroso-N-methylethylamine	2.0E-02 ca	8.7E-02 ca	3.1E-04 ca	3.1E-03 ca
2.1E+00 I		2.1E+00 I		0	0.10	930-55-2	N-Nitrosopyrrolidine	2.1E-01 ca	9.1E-01 ca	3.1E-03 ca	3.2E-02 ca
	1.0E-02 h		1.0E-02 r	0	0.10	99-08-1	m-Nitrotoluene	6.5E+02 nc	6.6E+03 nc	3.7E+01 nc	3.7E+02 nc
	1.0E-02 h		1.0E-02 r	0	0.10	99-99-0	p-Nitrotoluene	6.5E+02 nc	6.6E+03 nc	3.7E+01 nc	3.7E+02 nc
	4.0E-02 I		4.0E-02 r	0	0.10	27314-13-2	Norflurazon				
	7.0E-04 I		7.0E-04 r	0	0.10	85509-19-9	NuStar	4.6E+01 nc	4.8E+02 nc	2.6E+00 nc	2.6E+01 nc
	3.0E-03 I		3.0E-03 r	0	0.10	32536-52-0	Octabromodiphenyl ether	2.0E+02 nc	2.0E+03 nc	1.1E+01 nc	1.1E+02 nc
	5.0E-02 I		5.0E-02 r	0	0.10	2691-41-0	Octahydro-1357-tetranitro-1357- tetrazocine (HMX)	3.3E+03 nc	3.4E+04 nc	1.8E+02 nc	1.8E+03 nc
	2.0E-03 h		2.0E-03 r	0	0.10	152-16-9	Octamethylpyrophosphoramide	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
	5.0E-02 I		5.0E-02 r	0	0.10	19044-88-3	Oryzalin	3.3E+03 nc	3.4E+04 nc	1.8E+02 nc	1.8E+03 nc
	5.0E-03 I		5.0E-03 r	0	0.10	19666-30-9	Oxadiazon	3.3E+02 nc	3.4E+03 nc	1.8E+01 nc	1.8E+02 nc
	2.5E-02 I		2.5E-02 r	0	0.10	23135-22-0	Oxamyl	1.6E+03 nc	1.7E+04 nc	9.1E+01 nc	9.1E+02 nc
	3.0E-03 I		3.0E-03 r	0	0.10	42874-03-3	Oxyfluorfen	2.0E+02 nc	2.0E+03 nc	1.1E+01 nc	1.1E+02 nc
	1.3E-02 I		1.3E-02 r	0	0.10	78736-62-0	Paclobutrazol	6.5E+02 nc	6.6E+03 nc	4.7E+01 nc	4.7E+02 nc
	4.5E-03 I		4.5E-03 r	0	0.10	4685-14-7	Paraquat	2.9E+02 nc	3.1E+03 nc	1.6E+01 nc	1.6E+02 nc
	6.0E-03 h		6.0E-03 r	0	0.10	56-38-2	Parathion	3.9E+02 nc	4.1E+03 nc	2.2E+01 nc	2.2E+02 nc
	5.0E-02 h		5.0E-02 r	0	0.10	1114-71-2	Pebulate	3.3E+03 nc	3.4E+04 nc	1.8E+02 nc	1.8E+03 nc
	4.0E-02 I		4.0E-02 r	0	0.10	40487-42-1	Pendimethalin	2.6E+03 nc	2.7E+04 nc	1.5E+02 nc	1.5E+03 nc
2.3E-02 h		2.3E-02 r		0	0.10	87-84-3	Pentabromo-6-chloro cyclohexane	1.9E+01 ca	6.3E+01 ca	2.9E-01 ca	2.9E+00 ca

	2.0E-03 I		2.0E-03 r	0	0.10	1163-19-5	Pentabromodiphenyl ether	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
	8.0E-04 I		8.0E-04 r	0	0.10	608-93-5	Pentachlorobenzene	5.2E+01 nc	5.5E+02 nc	2.9E+00 nc	2.9E+01 nc
2.6E-01 h	3.0E-03 I	2.6E-01 r	3.0E-03 r	0	0.10	82-68-8	Pentachloronitrobenzene	1.7E+00 ca*	7.3E+00 ca	2.6E-02 ca	2.6E-01 ca
1.2E-01 I	3.0E-02 I	1.2E-01 r	3.0E-02 r	0	0.25	87-86-5	Pentachlorophenol	2.5E+00 ca	7.9E+00 ca	5.6E-02 ca	5.6E-01 ca
	5.0E-02 I		5.0E-02 r	0	0.10	52645-53-1	Permethrin	3.3E+03 nc	3.4E+04 nc	1.6E+02 nc	1.6E+03 nc
	2.5E-01 I		2.5E-01 r	0	0.10	13684-63-4	Phenmedipham	1.6E+04 nc	1.0E+05 max	9.1E+02 nc	9.1E+03 nc
	6.0E-01 I		6.0E-01 r	0	0.10	108-95-2	Phenol	3.9E+04 nc	1.0E+05 max	2.2E+03 nc	2.2E+04 nc
	6.0E-03 I		6.0E-03 r	0	0.10	108-45-2	m-Phenylenediamine	3.9E+02 nc	4.1E+03 nc	2.2E+01 nc	2.2E+02 nc
	1.9E-01 h		1.9E-01 r	0	0.10	106-50-3	p-Phenylenediamine	1.2E+04 nc	1.0E+05 max	6.9E+02 nc	6.9E+03 nc
	8.0E-05 I		8.0E-05 r	0	0.10	62-38-4	Phenylmercuric acetate	5.2E+00 nc	5.5E+01 nc	2.9E-01 nc	2.9E+00 nc
1.9E-03 h		1.9E-03 r		0	0.10	90-43-7	2-Phenylphenol	2.3E+02 ca	9.6E+02 ca	3.5E+00 ca	3.5E+01 ca
	2.0E-04 h		2.0E-04 r	0	0.10	298-02-2	Phorate	1.3E+01 nc	1.4E+02 nc	7.3E-01 nc	7.3E+00 nc
	2.0E-02 I		2.0E-02 r	0	0.10	732-11-6	Phosmet	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	3.0E-04 h		8.6E-05 I	0	0.10	7803-51-2	Phosphine	2.0E+01 nc	2.0E+02 nc	3.1E-01 nc	1.1E+01 nc
	2.0E-05 I		2.0E-05 r	0	0.10	7723-14-0	Phosphorus (white)			7.3E-02 nc	
	1.0E+00 h		1.0E+00 r	0	0.10	100-21-0	p-Phthalic acid			3.7E+03 nc	
	2.0E+00 I		3.4E-02 h	0	0.10	85-44-9	Phthalic anhydride			1.2E+02 nc	
	7.0E-02 I		7.0E-02 r	0	0.10	1918-02-1	Picloram	4.6E+03 nc	4.8E+04 nc	2.6E+02 nc	2.6E+03 nc
	1.0E-02 I		1.0E-02 r	0	0.10	23505-41-1	Pirimiphos-methyl	6.5E+02 nc	6.8E+03 nc	3.7E+01 nc	3.7E+02 nc
6.6E+00 h	7.0E-06 h	6.6E+00 r	7.0E-06 r	0	0.10		Polybrominated biphenyls	5.0E-02 ca**	2.1E-01 ca*	7.6E-04 ca*	7.6E-03 ca*
7.7E+00 I		7.7E+00 r		0	0.06	1336-36-3	Polychlorinated biphenyls (PCBs)	6.6E-02 ca*	3.4E-01 ca*	8.7E-04 ca*	8.7E-03 ca*
	7.0E-05 I		7.0E-05 r	0	0.06	12674-11-2	Aroclor 1016 (see PCBs for cancer endpoint)	4.6E+00 nc	8.5E+01 nc	2.6E-01 nc	2.6E+00 nc
	2.0E-05 I		2.0E-05 r	0	0.06	11097-69-1	Aroclor 1254 (see PCBs for cancer endpoint)	1.4E+00 nc	1.9E+01 nc	7.3E-02 nc	7.3E-01 nc
					0.10		Polynuclear aromatic hydrocarbons (PAHs)				
	6.0E-02 I		6.0E-02 r	1	0.10	1.4E+06 83-32-9	Acenaphthene	3.6E+02 sat	3.6E+02 sat	2.2E+02 nc	3.7E+02 nc
	3.0E-01 I		3.0E-01 r	1	0.10	1.5E+06 120-12-7	Anthracene	1.9E+01 sat	1.9E+01 sat	1.1E+03 nc	1.8E+03 nc
7.3E-01 e		7.3E-01 r		0	0.10	56-55-3	Benz[a]anthracene	6.1E-01 ca	2.6E+00 ca	9.2E-03 ca	9.2E-02 ca
7.3E-01 e		7.3E-01 r		0	0.10	205-99-2	Benzo[b]fluoranthene	6.1E-01 ca	2.6E+00 ca	9.2E-03 ca	9.2E-02 ca
7.3E-02 e		7.3E-02 r		0	0.10	207-08-9	Benzo[k]fluoranthene	6.1E+00 ca	2.6E+01 ca	9.2E-02 ca	9.2E-01 ca
							CAL-Modified PRG (PEA, 1994)	6.1E-01			
7.3E+00 I		7.3E+00 r		0	0.10	50-32-8	Benzo[a]pyrene	6.1E-02 ca	2.6E-01 ca	9.2E-04 ca	9.2E-03 ca
							CAL-Modified PRG (PEA, 1994)				1.5E-03
7.3E-03 e		7.3E-03 r		0	0.10	3.6E+07 218-01-9	Chrysene	2.4E+01 sat	2.4E+01 sat	9.2E-01 ca	9.2E+00 ca
							CAL-Modified PRG (PEA, 1994)	6.1E+00			
7.3E+00 e		7.3E+00 r		0	0.10	53-70-3	Dibenz[ah]anthracene	6.1E-02 ca	2.6E-01 ca	9.2E-04 ca	9.2E-03 ca
	4.0E-02 I		4.0E-02 r	0	0.10	206-44-0	Fluoranthene	2.6E+03 nc	2.7E+04 nc	1.5E+02 nc	1.5E+03 nc
	4.0E-02 I		4.0E-02 r	1	0.10	7.6E+05 86-73-7	Fluorene	3.0E+02 sat	3.0E+02 sat	1.5E+02 nc	2.4E+02 nc
7.3E-01 e		7.3E-01 r		0	0.10	193-39-5	Indeno[1,2,3-cd]pyrene	6.1E-01 ca	2.6E+00 ca	9.2E-03 ca	9.2E-02 ca
	4.0E-02 e		4.0E-02 r	1	0.10	7.1E+04 91-20-3	Naphthalene	6.0E+02 sat	6.0E+02 sat	1.5E+02 nc	2.4E+02 nc
	3.0E-02 I		3.0E-02 r	0	0.10	129-00-0	Pyrene	2.0E+03 nc	2.0E+04 nc	1.1E+02 nc	1.1E+03 nc
1.5E-01 I	9.0E-03 I	1.5E-01 r	9.0E-03 r	0	0.10	67747-09-5	Prochloraz	3.0E+00 ca	1.3E+01 ca	4.5E-02 ca	3.3E+02 ca
	6.0E-03 h		6.0E-03 r	0	0.10	26399-36-0	Profluralin	3.9E+02 nc	4.1E+03 nc	2.2E+01 nc	2.2E+02 nc
	1.5E-02 I		1.5E-02 r	0	0.10	1610-18-0	Prometon	9.6E+02 nc	1.0E+04 nc	5.5E+01 nc	5.5E+02 nc
	4.0E-03 I		4.0E-03 r	0	0.10	7287-19-6	Prometryn	2.6E+02 nc	2.7E+03 nc	1.5E+01 nc	1.5E+02 nc
	7.5E-02 I		7.5E-02 r	0	0.10	23950-58-5	Pronamide	4.6E+03 nc	5.1E+04 nc	2.7E+02 nc	2.7E+03 nc
	1.3E-02 I		1.3E-02 r	0	0.10	1918-16-7	Propachlor	8.5E+02 nc	8.9E+03 nc	4.7E+01 nc	4.7E+02 nc
	6.0E-03 I		6.0E-03 r	0	0.10	709-98-8	Propanil	3.3E+02 nc	3.4E+03 nc	1.8E+01 nc	1.8E+02 nc
	2.0E-02 I		2.0E-02 r	0	0.10	2312-35-8	Propargite	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	2.0E-03 I		2.0E-03 r	0	0.10	107-19-7	Propargyl alcohol	1.3E+02 nc	1.4E+03 nc	7.3E+00 nc	7.3E+01 nc
	2.0E-02 I		2.0E-02 r	0	0.10	139-40-2	Propazine	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	2.0E-02 I		2.0E-02 r	0	0.10	122-42-9	Propham	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	1.3E-02 I		1.3E-02 r	0	0.10	60207-90-1	Propiconazole	8.5E+02 nc	8.9E+03 nc	4.7E+01 nc	4.7E+02 nc
	2.0E+01 h		2.0E+01 r	0	0.10	57-55-6	Propylene glycol	1.0E+05 max	1.0E+05 max	7.3E+04 nc	7.3E+05 nc
	7.0E-01 h		7.0E-01 r	0	0.10	111-35-3	Propylene glycol, monoethyl ether	4.6E+04 nc	1.0E+05 max	2.6E+03 nc	2.6E+04 nc
	7.0E-01 h		5.7E-01 I	0	0.10	107-98-2	Propylene glycol, monomethyl ether	4.6E+04 nc	1.0E+05 max	2.1E+03 nc	2.6E+04 nc
2.4E-01 I	6.6E-03 r	1.3E-02 I	6.6E-03 I	1	0.10	75-56-9	Propylene oxide			5.2E-01 ca	2.2E-01 ca
	2.5E-01 I		2.5E-01 r	0	0.10	81335-77-5	Pursuit	1.6E+04 nc	1.0E+05 max	9.1E+02 nc	9.1E+03 nc
	2.5E-02 I		2.5E-02 r	0	0.10	51630-58-1	Pydrin	1.6E+03 nc	1.7E+04 nc	9.1E+01 nc	9.1E+02 nc
	1.0E-03 I		1.0E-03 r	0	0.10	110-86-1	Pyridine	6.5E+01 nc	6.8E+02 nc	3.7E+00 nc	3.7E+01 nc
	5.0E-04 I		5.0E-04 r	0	0.10	13593-03-8	Quinalphos	3.3E+01 nc	3.4E+02 nc	1.8E+00 nc	1.8E+01 nc
1.2E+01 h		1.2E+01 r		0	0.10	91-22-5	Quinoline	3.7E-02 ca	1.6E-01 ca	5.6E-04 ca	5.6E-03 ca
1.1E-01 I	3.0E-03 I	1.1E-01 r	3.0E-03 r	0	0.10	121-82-4	RDX (Cyclonite)	4.0E+00 ca*	1.7E+01 ca	6.1E-02 ca	6.1E-01 ca
	3.0E-02 I		3.0E-02 r	0	0.10	10453-86-8	Resmethrin	2.0E+03 nc	2.0E+04 nc	1.1E+02 nc	1.1E+03 nc
	5.0E-02 h		5.0E-02 r	0	0.10	299-84-3	Ronnel	3.3E+03 nc	3.4E+04 nc	1.8E+02 nc	1.8E+03 nc
	4.0E-03 I		4.0E-03 r	0	0.10	83-79-4	Rotenone	2.6E+02 nc	2.7E+03 nc	1.5E+01 nc	1.5E+02 nc
	2.5E-02 I		2.5E-02 r	0	0.10	76578-05-0	Savey	1.6E+03 nc	1.7E+04 nc	9.1E+01 nc	9.1E+02 nc
	5.0E-03 I			0	0.10	7783-00-8	Selenious Acid	3.3E+02 nc	3.4E+03 nc		1.8E+02 nc
	5.0E-03 I			0	0.01	7782-49-2	Selenium	3.8E+02 nc	8.5E+03 nc		1.8E+02 nc
	5.0E-03 h			0	0.10	630-10-4	Selenourea	3.3E+02 nc	3.4E+03 nc		1.8E+02 nc
	9.0E-02 I		9.0E-02 r	0	0.10	74051-80-2	Sethoxydim	5.9E+03 nc	6.1E+04 nc	3.3E+02 nc	3.3E+03 nc
	5.0E-03 I			0	0.01	7440-22-4	Silver and compounds	3.8E+02 nc	8.5E+03 nc		1.8E+02 nc
1.2E-01 h	5.0E-03 I	1.2E-01 r	2.0E-03 r	0	0.10	122-34-9	Simazine	3.7E+00 ca*	1.6E+01 ca*	5.6E-02 ca	5.6E-01 ca
	4.0E-03 I		4.0E-03 r	0	0.10	26628-22-8	Sodium azide	2.6E+02 nc	2.7E+03 nc	1.5E+01 nc	1.5E+02 nc
2.7E-01 h	3.0E-02 I	2.7E-01 r	3.0E-02 r	0	0.10	148-18-5	Sodium diethyldithiocarbamate	1.6E+00 ca	7.1E+00 ca	2.5E-02 ca	2.5E-01 ca
	[illegible]E-05 I		2.0E-05 r	0	0.10	62-74-8	Sodium fluoroacetate	1.3E+00 nc	1.4E+01 nc	7.3E-02 n	7.3E-01 nc

	1.0E-03 h		1.0E-03 r	0	0.10		13718-26-8	Sodium metavanadate	6.5E+01 nc	6.6E+02 nc	3.7E+00 nc	3.7E+01 nc
	6.0E-01 l			0	0.01		7440-24-6	Strontium, stable	4.6E+04 nc	1.0E+05 max		2.2E+04 nc
	3.0E-04 l		3.0E-04 r	0	0.10		57-24-9	Strychnine	2.0E+01 nc	2.0E+02 nc	1.1E+00 nc	1.1E+01 nc
	2.0E-01 l		2.9E-01 l	1	0.10	2.8E+04	100-42-5	Styrene	2.2E+03 sat	2.2E+03 sat	1.1E+03 nc	1.6E+03 nc
	2.5E-02 l		2.5E-02 r	0	0.10		88871-89-0	Systhane	1.6E+03 nc	1.7E+04 nc	9.1E+01 nc	9.1E+02 nc
1.5E+05 h		1.5E+05 h		0	0.03		1746-01-6	2,3,7,8-TCDD (dioxin)	3.6E-06 ca	2.4E-05 ca	4.5E-06 ca	4.5E-07 ca
	7.0E-02 l		7.0E-02 r	0	0.10		34014-18-1	Tebuthiuron	4.6E+03 nc	4.6E+04 nc	2.6E+02 nc	2.6E+03 nc
	2.0E-02 h		2.0E-02 r	0	0.10		3383-96-8	Temephos	1.3E+03 nc	1.4E+04 nc	7.3E+01 nc	7.3E+02 nc
	1.3E-02 l		1.3E-02 r	0	0.10		5902-51-2	Terbacil	8.5E+02 nc	8.9E+03 nc	4.7E+01 nc	4.7E+02 nc
	2.5E-05 h		2.5E-05 r	0	0.10		13071-79-9	Terbufos	1.6E+00 nc	1.7E+01 nc	9.1E-02 nc	9.1E-01 nc
	1.0E-03 l		1.0E-03 r	0	0.10		886-50-0	Terbutryn	6.5E+01 nc	6.6E+02 nc	3.7E+00 nc	3.7E+01 nc
	3.0E-04 l		3.0E-04 r	0	0.10		95-94-3	1,2,4,5-Tetrachlorobenzene	2.0E+01 nc	2.0E+02 nc	1.1E+00 nc	1.1E+01 nc
2.6E-02 l	3.0E-02 l	2.6E-02 l	3.0E-02 r	1	0.10	2.6E+04	630-20-6	1,1,1,2-Tetrachloroethane	4.6E+00 ca	1.2E+01 ca	2.6E-01 ca	4.3E-01 ca
2.0E-01 l		2.0E-01 l		1	0.10	4.5E+04	79-34-5	1,1,2,2-Tetrachloroethane	9.0E-01 ca	2.4E+00 ca	3.3E-02 ca	5.5E-02 ca
5.2E-02 e	1.0E-02 l	2.0E-03 e	1.0E-02 r	1	0.10	1.2E+04	127-18-4	Tetrachloroethylene (PCE)	7.0E+00 ca	2.5E+01 ca	3.3E+00 ca	1.1E+00 ca
								CAL-Modified PRG (PEA, 1994)			3.2E-01	
	3.0E-02 l		3.0E-02 r	0	0.10		58-90-2	2,3,4,6-Tetrachlorophenol	2.0E+03 nc	2.0E+04 nc	1.1E+02 nc	1.1E+03 nc
2.0E+01 h		2.0E+01 r		0	0.10		5216-25-1	p,a,a,a-Tetrachlorotoluene	2.2E-02 ca	9.5E-02 ca	3.4E-04 ca	3.4E-03 ca
2.4E-02 h	3.0E-02 l	2.4E-02 r	3.0E-02 r	0	0.10		961-11-5	Tetrachlorovinphos	1.9E+01 ca	7.9E+01 ca	2.8E-01 ca	2.8E+00 ca
	5.0E-04 l		5.0E-04 r	0	0.10		3689-24-5	Tetraethyldithiopyrophosphate	3.3E+01 nc	3.4E+02 nc	1.8E+00 nc	1.8E+01 nc
	7.0E-05 h			0	0.01		1314-32-5	Thallic oxide	5.4E+00 nc	1.2E+02 nc		2.6E+00 nc
	9.0E-05 l			0	0.01		563-68-8	Thallium acetate	6.9E+00 nc	1.5E+02 nc		3.3E+00 nc
	8.0E-05 l			0	0.01		6533-73-9	Thallium carbonate	6.1E+00 nc	1.4E+02 nc		2.9E+00 nc
	8.0E-05 l			0	0.01		7791-12-0	Thallium chloride	6.1E+00 nc	1.4E+02 nc		2.9E+00 nc
	9.0E-05 l			0	0.01		10102-45-1	Thallium nitrate	6.9E+00 nc	1.5E+02 nc		3.3E+00 nc
	9.0E-05 x			0	0.01		12039-52-0	Thallium selenite	6.9E+00 nc	1.5E+02 nc		3.3E+00 nc
	8.0E-05 l			0	0.01		7446-18-6	Thallium sulfate	6.1E+00 nc	1.4E+02 nc		2.9E+00 nc
	1.0E-02 l		1.0E-02 r	0	0.10		28249-77-6	Thiobencarb	6.5E+02 nc	6.6E+03 nc	3.7E+01 nc	3.7E+02 nc
	3.0E-02 x		3.0E-02 r	0	0.10		3689-24-5	2-(Thiocyanomethylthio)-benzothiazole (TCMTB)	2.0E+03 nc	2.0E+04 nc	1.1E+02 nc	1.1E+03 nc
	3.0E-04 h		3.0E-04 r	0	0.10		39196-18-4	Thiofanox	2.0E+01 nc	2.0E+02 nc	1.1E+00 nc	1.1E+01 nc
	8.0E-02 l		8.0E-02 r	0	0.10		23564-05-8	Thiophanate-methyl	5.2E+03 nc	5.5E+04 nc	2.9E+02 nc	2.9E+03 nc
	5.0E-03 l		5.0E-03 r	0	0.10		137-26-8	Thiram	3.3E+02 nc	3.4E+03 nc	1.8E+01 nc	1.8E+02 nc
	8.0E-01 h			0	0.01		n/a	Tin (inorganic, see tributyltin oxide for organic tin)	4.6E+04 nc	1.0E+05 max		2.2E+04 nc
	2.0E-01 l		1.1E-01 h	1	0.10	1.3E+04	108-88-3	Toluene	1.9E+03 nc	2.8E+03 sat	4.0E+02 nc	7.2E+02 nc
3.2E+00 h		3.2E+00 r		0	0.10		95-80-7	Toluene-2,4-diamine	1.4E-01 ca	6.0E-01 ca	2.1E-03 ca	2.1E-02 ca
	8.0E-01 h		8.0E-01 r	0	0.10		95-70-5	Toluene-2,5-diamine	3.9E+04 nc	1.0E+05 max	2.2E+03 nc	2.2E+04 nc
	2.0E-01 h		2.0E-01 r	0	0.10		823-40-5	Toluene-2,6-diamine	1.3E+04 nc	1.0E+05 max	7.3E+02 nc	7.3E+03 nc
1.9E-01 l		1.9E-01 r		0	0.10		106-49-0	p-Toluidine	2.3E+00 ca	1.0E+01 ca	3.5E-02 ca	3.5E-01 ca
1.1E+00 l		1.1E+00 l		0	0.10		8001-35-2	Toxaphene	4.0E-01 ca	1.7E+00 ca	6.0E-03 ca	6.1E-02 ca
	7.5E-03 l		7.5E-03 r	0	0.10		66841-25-6	Tralomethrin	4.6E+02 nc	5.1E+03 nc	2.7E+01 nc	2.7E+02 nc
	1.3E-02 l		1.3E-02 r	0	0.10		2303-17-5	Triallate	8.5E+02 nc	8.9E+03 nc	4.7E+01 nc	4.7E+02 nc
	1.0E-02 l		1.0E-02 r	0	0.10		82097-50-5	Triasulfuron	6.5E+02 nc	6.6E+03 nc	3.7E+01 nc	3.7E+02 nc
	5.0E-03 l		5.0E-03 r	0	0.10		615-54-3	1,2,4-Tribromobenzene	3.3E+02 nc	3.4E+03 nc	1.8E+01 nc	1.8E+02 nc
	3.0E-05 l		3.0E-05 r	0	0.10		56-35-9	Tributyltin oxide (TBTO)	2.0E+00 nc	2.0E+01 nc	1.1E-01 nc	1.1E+00 nc
3.4E-02 h		3.4E-02 r		0	0.10		634-93-5	2,4,6-Trichloroaniline	1.3E+01 ca	5.6E+01 ca	2.0E-01 ca	2.0E+00 ca
2.9E-02 h		2.9E-02 r		0	0.10		33663-50-2	2,4,6-Trichloroaniline hydrochloride	1.5E+01 ca	6.6E+01 ca	2.3E-01 ca	2.3E+00 ca
	1.0E-02 l		5.7E-02 h	1	0.10	1.5E+05	120-82-1	1,2,4-Trichlorobenzene	6.2E+02 nc	5.5E+03 sat	2.1E+02 nc	1.9E+02 nc
	9.0E-02 h		2.9E-01 x	1	0.10	1.5E+04	71-55-6	1,1,1-Trichloroethane	3.0E+03 sat	3.0E+03 sat	1.0E+03 nc	1.3E+03 nc
5.7E-02 l	4.0E-03 l	5.6E-02 l	4.0E-03 r	1	0.10	1.4E+04	79-00-5	1,1,2-Trichloroethane	1.4E+00 ca	3.3E+00 ca	1.2E-01 ca	2.0E-01 ca
1.1E-02 e	6.0E-03 e	6.0E-03 e	6.0E-03 r	1	0.10	7.6E+03	79-01-6	Trichloroethylene (TCE)	7.1E+00 ca*	1.7E+01 ca*	1.1E+00 ca*	1.6E+00 ca*
	3.0E-01 l		2.0E-01 h	1	0.10	2.3E+03	75-69-4	Trichlorofluoromethane	7.1E+02 nc	2.4E+03 nc	7.3E+02 nc	1.3E+03 nc
	1.0E-01 l		1.0E-01 r	0	0.10		95-95-4	2,4,5-Trichlorophenol	6.5E+03 nc	6.6E+04 nc	3.7E+02 nc	3.7E+03 nc
1.1E-02 l		1.1E-02 l		0	0.10		88-06-2	2,4,6-Trichlorophenol	4.0E+01 ca	1.7E+02 ca	6.2E-01 ca	6.1E+00 ca
	1.0E-02 l		1.0E-02 r	0	0.10		93-76-5	2,4,5-Trichlorophenoxyacetic Acid	6.5E+02 nc	6.6E+03 nc	3.7E+01 nc	3.7E+02 nc
	8.0E-03 l		8.0E-03 r	0	0.10		93-72-1	2-(2,4,5-Trichlorophenoxy) propionic acid	5.2E+02 nc	5.5E+03 nc	2.9E+01 nc	2.9E+02 nc
	5.0E-03 l		5.0E-03 r	1	0.10	7.7E+03	598-77-6	1,1,2-Trichloropropane	5.1E+01 nc	1.9E+02 nc	1.8E+01 nc	3.0E+01 nc
7.0E+00 h	6.0E-03 l	7.0E+00 r	5.0E-03 r	1	0.10	7.7E+03	96-18-4	1,2,3-Trichloropropane	6.8E-03 ca	1.5E-02 ca	9.6E-04 ca	1.6E-03 ca
	5.0E-03 h		5.0E-03 r	1	0.10	1.2E+04	96-19-5	1,2,3-Trichloropropene	7.5E+01 nc	2.9E+02 nc	1.8E+01 nc	3.0E+01 nc
	3.0E+01 l		6.6E+00 h	1	0.10	3.1E+03	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	4.1E+03 sat	4.1E+03 sat	3.1E+04 nc	5.9E+04 nc
	3.0E-03 l		3.0E-03 r	0	0.10		58138-08-2	Tridiphane	2.0E+02 nc	2.0E+03 nc	1.1E+01 nc	1.1E+02 nc
	2.0E-03 r		2.0E-03 l	1	0.10	6.3E+03	121-44-8	Triethylamine	2.2E+01 nc	6.0E+01 nc	7.3E+00 nc	1.2E+01 nc
7.7E-03 l	7.5E-03 l	7.7E-03 r	7.5E-03 r	0	0.10		1582-09-8	Trifluralin	5.6E+01 ca**	2.5E+02 ca*	8.7E-01 ca*	8.7E+00 ca*
3.7E-02 h		3.7E-02 r		0	0.10		512-56-1	Trimethyl phosphate	1.2E+01 ca	5.2E+01 ca	1.8E-01 ca	1.8E+00 ca
	5.0E-05 l		5.0E-05 r	0	0.10		99-35-4	1,3,5-Trinitrobenzene	3.3E+00 nc	3.4E+01 nc	1.8E-01 nc	1.8E+00 nc
	1.0E-02 h		1.0E-02 r	0	0.10		479-45-8	Trinitrophenylmethylnitramine	6.5E+02 nc	6.8E+03 nc	3.7E+01 nc	3.7E+02 nc
3.0E-02 l	5.0E-04 l	3.0E-02 r	5.0E-04 r	0	0.10		118-96-7	2,4,6-Trinitrotoluene	1.5E+01 ca**	6.4E+01 ca**	2.2E-01 ca**	2.2E+00 ca**
	3.0E-03 l			0	0.01		7440-61-1	Uranium (soluble salts)	2.3E+02 nc	5.1E+03 nc		1.1E+02 nc
	7.0E-03 h			0	0.01		7440-62-2	Vanadium	5.4E+02 nc	1.2E+04 nc		2.6E+02 nc
	9.0E-03 l			0	0.01		1314-62-1	Vanadium pentoxide	6.8E+02 nc	1.5E+04 nc		3.3E+02 nc
	2.0E-02 h			0	0.01		27774-13-6	Vanadyl sulfate	1.5E+03 nc	3.4E+04 nc		7.3E+02 nc
	2.0E-02 h			0	0.01		13701-70-7	Vanadium sulfate	1.5E+03 nc	3.4E+04 nc		7.3E+02 nc
	1.0E-03 l		1.0E-03 r	0	0.10		1929-77-7	Vernam	6.5E+01 nc	6.6E+02 nc	3.7E+00 nc	3.7E+01 nc
	2.5E-02 l		2.5E-02 r	0	0.10		50471-44-8	Vinclozolin	1.6E+03 nc	1.7E+04 nc	9.1E+01 nc	9.1E+02 nc
	1.0E+00 h		5.7E-02 l	0	0.10		108-05-4	Vinyl acetate	6.5E+04 nc	1.0E+05 max	2.1E+02 nc	3.7E+04 nc
1.9E+00 h		3.0E-01 h		1	0.10	2.4E+02	75-01-4	Vinyl chloride	5.2E-03 ca	1.1E-02 ca	2.2E-02 ca	2.0E-02 ca

3.0E-04 I	3.0E-04 r	0	0.10		81-81-2	Warfarin	2.0E+01 nc	2.0E+02 nc	1.1E+00 nc	1.1E+01 nc
2.0E+00 I	2.0E-01 x	1	0.10	4.1E+04	108-38-3	m-Xylene	9.9E+02 sat	9.9E+02 sat	7.3E+02 nc	1.4E+03 nc
2.0E+00 I	2.0E-01 x	1	0.10	5.8E+04	95-47-6	o-Xylene	9.9E+02 sat	9.9E+02 sat	7.3E+02 nc	1.4E+03 nc
		1	0.10	4.1E+04	106-42-3	p-Xylene	9.9E+02 sat	9.9E+02 sat		
2.0E+00 I	2.0E-01 r	1	0.10	4.7E+04	1330-20-7	Xylene (mixed)	9.9E+02 sat	9.9E+02 sat	7.3E+02 nc	1.4E+03 nc
3.0E-01 I		0	0.01		7440-66-6	Zinc	2.3E+04 nc	1.0E+05 max		1.1E+04 nc
3.0E-04 I		0	0.01		1314-84-7	Zinc phosphide	2.3E+01 nc	5.1E+02 nc		1.1E+01 nc
5.0E-02 I	5.0E-02 r	0	0.10		12122-67-7	Zineb	3.3E+03 nc	3.4E+04 nc	1.8E+02 nc	1.8E+03 nc

APPENDIX B

RESIDUAL RISK CALCULATIONS
RISK ASSUMPTIONS AND UNCERTANTIES

TABLE B.1-1

SUMMARY OF SITE INVESTIGATION, RISK, AND PROPOSED SOIL REMOVAL QUANTITIES
WASTE PILE 6

Site	Site Name	Area Description	Impacted Area (ft^2) & Volume (cy) (1)	Constituents of Concern (COCs) (1)	COC Concentration (1) (mg/kg)	PRG or Bkgnd Concentration (1) (mg/kg)	Hazard Index (1)	Cancer Risk (1)	Lead Risk (1)	Soil Sample No (1)	Soil Removal Quantity (2)
22	Waste Pile 6	Car Battery Area	7 ft^2 (0.2 cy)	Antimony	823	63	27	2.0E-12	Yes	S010	7 ft^2 (0.2 cy)
				Lead	5,910	400					
		Radio Battery Area	800 ft^2 (30 cy)	Antimony	71	63	12	3.0E-08	Yes	S012	800 ft^2 (30 cy)
				Cadmium	41.9	38					
				Lead	1,560	400					
		Unknown Battery Area	7 ft^2 (0.2 cy)	Lead	3,410	400	nc	nc	Yes	S015	7 ft^2 (0.2 cy)
		Asphalt Drum Pile	1,300 ft^2 (49 cy)	B(a)A	1.9	0.61	3	3.0E-04	Yes	S145	1,300 ft^2 (49 cy)
				B(a)P	1.5	0.061				S146	
				B(b)F	7.6	0.61				S147	
				Arsenic	73.8	62				S165	
				Chromium	1,270	1,080				S166	
				Lead	903	400				S167/S168	
		Roofing Material Pile	50 ft^2 (3.5 cy)	B(a)P	15	0.061	3	5.0E-04	No	S148	50 ft^2 (3.5 cy)
				B(b)F	32	0.61					
				I(123cd)P	5.6	0.61					
		Metal Debris Pile	78 ft^2 (25 cy)	Cadmium	183	38	6	1.0E-07	No	S163	78 ft^2 (25 cy)
		Empty Drum Pile	70 ft^2 (12 cy)	Chromium	1,290	1,080	0.01	3.0E-05	Yes	S164	70 ft^2 (12 cy)

(1) Source: Operable Unit 3 Remedial Investigation Report - Final (December 1996).
(2) Source: Operable Unit 3 Focused Feasibility Study Report (January 1997).

TABLE B.1-2

DATA SUMMARY AND SCREENING FOR MAXIMUM RESIDUAL CONCENTRATIONS (1)
WASTE PILE 6

Sample Number	Concentration (mg/kg)																				
	Antimony	Arsenic	Cadmium	Chromium		Lead	Ar-1254	Ar-1260	alpha-Chlordane	gamma-Chlordane	4,4-DDD	4,4-DDE	4,4-DDT	b-BHC	B(a)A	B(a)P	B(b)F	I(123cd)P	DEHP	Dieldrin	Endrin
S009	ND	31.1	6.83	567		162 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
S011	ND	50.3	4.68	**1100**	(2)	70.1 J	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND	ND	NA	NA
S013	2.43 J	17.1	4.39	966		84 J	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND	ND	NA	NA
S014	ND	28.8	ND	663		72.7 J	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND	ND	NA	NA
S016	ND	21	2.59	759		**248** J	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND	ND	NA	NA
S017	ND	2.88	ND	117		8.94 J	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND	ND	NA	NA
S018	ND	0.395 J	ND	21	J	4.11 J	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND	ND	NA	NA
S019	ND	16.3	3.55	492		52.2	ND	ND	ND	ND	ND	0.0027 J	0.003 J	ND	ND	ND	ND	ND	ND	ND	ND
S020	ND	12.1	5.62	708		45.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
S021	ND	11.9	1.89	348		51	ND	ND	ND	ND	ND	0.00083 J	0.0031 J	ND	ND	ND	ND	ND	ND	ND	0.00052 J
S022	ND	18.9	6.03	994		108	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
S023	ND	21	6.54	1070		126	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
S024	ND	19.5	6.54	885		59.2	ND	ND	ND	ND	ND	0.015 J	0.0013 J	**0.00089** J	ND	ND	ND	ND	ND	ND	ND
S025	ND	21.2	4.86	894		127	ND	ND	ND	ND	**0.0044** J	**0.11** J	**0.0056** J	ND	ND	ND	ND	ND	ND	ND	ND
S033	14.3 J	44.5	6	947		73.1	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND	ND	NA	NA
S034	ND	32.1	**7.61**	1020		64.6	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND	**0.4**	NA	NA
S035	ND	30.1	5.5	709		41	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND	0.3 J	NA	NA
Maximum	14.3	50.3	7.61	1100		248 J	0	0	0	0	0.0044	0.11	0.0056	0.00089	0	0	0	0	0.4	0	0.00052
Background	63	62	6.5	1080		166															
Bkgnd Exceeded	No	No	Yes	No	(3)	Yes															
Average			5.2	721.2		82.2															

(1) Source of data: Operable Unit 3 Remedial Investigation Report - Final (December 1996).
(2) Bold indicates the maximum detected value for a given chemical.
(3) Concentration is not significantly greater than background, based on the conclusions of the RI Report.

TABLE B.1-3

RESIDENTIAL RESIDUAL HEALTH RISK EVALUATION
WASTE PILE 6

Constituent	Residential Region IX PRG (mg/kg) (1) Cancer	Residential Region IX PRG (mg/kg) (1) Noncancer	Exposure Point Concentration (2) (mg/kg)	EPC/PRG Ratio Cancer	EPC/PRG Ratio Noncancer	Residual ELCR (3)	Residual HI (4)
Cadmium	1400	38	7.61	0.0054	0.20	5.E-09	0.20
Lead	na	na	248	nc	nc	nc	nc
4,4-DDD	1.9	na	0.0044	0.0023	nc	2.E-09	nc
4,4-DDE	1.3	na	0.11	0.0846	nc	8.E-08	nc
4,4-DDT	1.3	33	0.0056	0.0043	0.00017	4.E-09	0.00017
beta-BHC	0.25	na	0.0009	0.0036	nc	4.E-09	nc
DEHP	32	1300	0.4	0.0125	0.00031	1.E-08	0.00031
Endrin	na	20	0.0005	nc	0.00003	nc	0.00003
					Total:	**1.E-07**	**0.20**

Notes:
(1) Source: Region IX Preliminary Remediation Goals (PRGs) Second Half 1995; refer to 'Appendix A'.
(2) The maximum concentration remaining over the entire area of Waste Pile 6 post-remediation was assumed as the exposure point concentration.
(3) Excludes risks associated with beryllium and chromium, which were determined in the RI Report to be representative of background.
(4) Excludes hazards associated with beryllium and manganese, which were determined in the RI Report to be representative of background.

ELCR - Excess lifetime cancer risk.
EPC - Exposure point concentration.
HI - Hazard Index.
na - Not available.
nc - Not calculated.
PRG - Region IX Preliminary Remediation Goal.

TABLE B.1-4

INDUSTRIAL RESIDUAL HEALTH RISK EVALUATION
WASTE PILE 6

Constituent	Residential Region IX PRG (mg/kg) (1)		Exposure Point Concentration (2)	EPC/PRG Ratio		Residual	Residual
	Cancer	Noncancer	(mg/kg)	Cancer	Noncancer	ELCR (3)	HI (4)
Cadmium	3000	850	7.61	0.0025	0.01	3.E-09	0.01
Lead	na	na	248	nc	nc	nc	nc
4,4-DDD	7.9	na	0.0044	0.0006	nc	6.E-10	nc
4,4-DDE	5.6	na	0.11	0.0196	nc	2.E-08	nc
4,4-DDT	5.6	340	0.0056	0.0010	0.00002	1.E-09	0.00002
beta-BHC	1.1	na	0.0009	0.0008	nc	8.E-10	nc
DEHP	140	14000	0.4	0.0029	0.00003	3.E-09	0.00003
Endrin	na	200	0.0005	nc	0.00000	nc	0.00000
					Total:	**3.E-08**	**0.01**

Notes:
(1) Source: Region IX Preliminary Remediation Goals (PRGs) Second Half 1995; refer to 'Appendix A'.
(2) The maximum concentration remaining over the entire area of Waste Pile 6 post-remediation was assumed as the exposure point concentration.
(3) Excludes risks associated with beryllium and chromium, which were determined in the RI Report to be representative of background.
(4) Excludes hazards associated with beryllium and manganese, which were determined in the RI Report to be representative of background.

ELCR - Excess lifetime cancer risk.
EPC - Exposure point concentration.
HI - Hazard Index.
na - Not available.
nc - Not calculated.
PRG - Region IX Preliminary Remediation Goal.

TABLE B.1-5

SUMMARY OF SITE INVESTIGATION, RISK, AND PROPOSED SOIL REMOVAL QUANTITIES
LANDFILL 29

Site	Site Name	Area Description	Impacted Area (ft^2) & Volume (cy) (1)	Constituents of Concern (COCs) (1)	COC Concentration (1) (mg/kg)	PRG or Bkgnd Concentration (1) (mg/kg)	Hazard Index (1)	Cancer Risk (1)	Lead Risk (1)	Soil Sample No (1)	Soil Removal Quantity (2)
24	Landfill 29	Surface Drum Area	175 ft2 (31 cy)	Antimony Lead	224 18,700	63 400	10	2.0E-04	Yes	S149 S150 S151	175 ft2 (31 cy)
		Subsurface Metal Area	52 ft2 (4 cy)	Antimony Lead	123 1,120	63 400	4	4.0E-13	Yes	S162	52 ft2 (4 cy)

(1) Source: Operable Unit 3 Remedial Investigation Report - Final (December 1996).
(2) Source: Operable Unit 3 Focused Feasibility Study Report (January 1997).

TABLE B.1-6

DATA SUMMARY AND SCREENING FOR MAXIMUM RESIDUAL CONCENTRATIONS (1)
LANDFILL 29

Sample Number	Concentration (mg/kg)																					
	Antimony		Arsenic		Manganese		Lead			Acetone		MEK		2-Hexanone		MIBK		Toluene	
S001	ND		0.378	J	43.4		7.86	J		NA		NA		NA		NA		NA	
S002	ND		18.6		1610		31.7	J		NA		NA		NA		NA		NA	
S003	ND		5		229		**321**	**J**	(2)	NA		NA		NA		NA		NA	
S004	ND		14.5		267		26.1	J		NA		NA		NA		NA		NA	
S005	ND		12.3		462		43.2	J		NA		NA		NA		NA		NA	
S006	18.2	J	17.3		1020		122	J		NA		NA		NA		NA		NA	
S007	ND		0.504	J	37.1	J	12	J		NA		NA		NA		NA		NA	
S138	ND		26.6		985		36.6			NA		NA		NA		NA		NA	
S139	ND		5.53		270		41.6			NA		NA		NA		NA		NA	
S140	6.12	J	40.2		386		85			NA		NA		NA		NA		NA	
S141	ND		9.2		280		18.9			NA		NA		NA		NA		NA	
S142	ND		9.15		241		18.2			NA		NA		NA		NA		NA	
S143	ND		2.72		226		54.5			NA		NA		NA		NA		NA	
S152	31.4		12.1		787		266			NA		NA		NA		NA		NA	
S153	11.2	J	58.9		3010		37.7			**0.018**	**J**	ND		0.0052	J	0.0047	J	0.0013	J
S154	16.6	J	61.5		4700		34.8			**0.018**	**J**	ND		NA		ND		ND	
S155	8.98	J	44.9		**5040**		33.3			0.0095	J	ND		ND		ND		ND	
S156	ND		56		1830		44.1			ND		ND		0.0047	J	0.0055	J	ND	
S157	15	J	35.7		1720		44.7			0.0		ND		ND		ND		**0.0022**	**J**
S158	**56.2**		2.51		103		30.3			ND		ND		ND		ND		ND	
S159	26.3	J	**71.3**		2380		41.9			0.0099	J	ND		ND		ND		ND	
S161	14.2	J	50.2		4890		34.8			0.013		**0.011**	**J**	**0.0091**	**J**	**0.010**	**J**	ND	
Maximum	56.2		71.3		5040		321	J		0.018	J	0.011	J	0.0091	J	0.010	J	0.0022	J
Background	63		62		3150		166												
Bkgnd Exceeded	No		No	(3)	No	(3)	Yes												
Average			25		1387		63												

(1) Source of data: Operable Unit 3 Remedial Investigation Report - Final (December 1996).
(2) Bold indicates the maximum detected value for a given chemical.
(3) Concentration is not significantly greater than background, based on the conclusions of the RI Report.

MEK - Methyl ethyl ketone (2-Butanone)
MIBK - Methyl isobutyl ketone (4-Methyl-2-pentanone)

TABLE B.1-7

RESIDENTIAL RESIDUAL HEALTH RISK EVALUATION
LANDFILL 29

Constituent	Residential Region IX PRG (mg/kg) (1)		Exposure Point Concentration (2) (mg/kg)	EPC/PRG Ratio		Residual ELCR (3)	Residual HI (4)
	Cancer	Noncancer		Cancer	Noncancer		
Lead	na	na	321 (5)	nc	nc	nc	nc
Acetone	na	2000	0.018	nc	0.00001	nc	0.00001
MEK	na	8700	0.011	nc	0.000001	nc	0.000001
2-Hexanone	na	na	0.0091	nc	nc	nc	nc
MIBK	na	5200	0.010	nc	0.000002	nc	0.000002
Toluene	na	1900	0.0022	nc	0.000001	nc	0.000001
					Total:	**nc**	**0.00001**

Notes:
(1) Source: Region IX Preliminary Remediation Goals (PRGs) Second Half 1995; refer to 'Appendix A'.
(2) The maximum concentration remaining over the entire area of Landfill 29 post-remediation is assumed to be the exposure point concentration.
(3) No carcinogenic chemicals at concentrations above background remain at Landfill 29 post-remediation; therefore, a residual ELCR was not calculated.
(4) Excludes hazards associated with arsenic and manganese, which were determined in the RI Report to be representative of background.
(5) The exposure point concentration for lead is below the residential screening criterion of 400 mg/kg.

ELCR - Excess lifetime cancer risk.
EPC - Exposure point concentration.
HI - Hazard Index.
MEK - Methyl ethyl ketone (2-Butanone)
MIBK - Methyl isobutyl ketone (4-Methyl-2-pentanone)
na - Not available.
nc - Not calculated.
PRG - Region IX Preliminary Remediation Goal.

TABLE B.1-8

INDUSTRIAL RESIDUAL HEALTH RISK EVALUATION
LANDFILL 29

Constituent	Residential Region IX PRG (mg/kg) (1) Cancer	Residential Region IX PRG (mg/kg) (1) Noncancer	Exposure Point Concentration (2) (mg/kg)	EPC/PRG Ratio Cancer	EPC/PRG Ratio Noncancer	Residual ELCR (3)	Residual HI (4)
Lead	na	na	321 (5)	nc	nc	nc	nc
Acetone	na	8434	0.018	nc	0.000002	nc	0.000002
MEK	na	33619	0.011	nc	0.0000003	nc	0.0000003
2-Hexanone	na	na	0.0091	nc	nc	nc	nc
MIBK	na	54487	0.010	nc	0.0000002	nc	0.0000002
Toluene	na	2800	0.0022	nc	0.000001	nc	0.000001
					Total:	**nc**	**0.000003**

Notes:
(1) Source: Region IX Preliminary Remediation Goals (PRGs) Second Half 1995; refer to 'Appendix A'.
(2) The maximum concentration remaining over the entire area of Landfill 29 post-remediation is assumed to be the exposure point concentration.
(3) No carcinogenic chemicals at concentrations above background remain at Landfill 29 post-remediation; therefore, a residual ELCR was not calculated.
(4) Excludes hazards associated with arsenic and manganese, which were determined in the RI Report to be representative of background.
(5) The exposure point concentration for lead is below the residential screening criterion of 400 mg/kg.

ELCR - Excess lifetime cancer risk.
EPC - Exposure point concentration.
HI - Hazard Index.
MEK - Methyl ethyl ketone (2-Butanone)
MIBK - Methyl isobutyl ketone (4-Methyl-2-pentanone)
na - Not available.
nc - Not calculated.
PRG - Region IX Preliminary Remediation Goal.

TABLE B.1-9

SUMMARY OF SITE INVESTIGATION, RISK, AND PROPOSED SOIL REMOVAL QUANTITIES
MARBO LAUNDRY

Site	Site Name	Area Description	Impacted Area (ft^2) & Volume (cy) (1)	Constituents of Concern (COCs) (1)	COC Concentration (1) (mg/kg)	PRG or Bkgnd Concentration (1) (mg/kg)	Hazard Index (1)	Cancer Risk (1)	Lead Risk (1)	Soil Sample No (1)	Soil Removal Quantity (2)
38	MARBO Laundry	Building Surrounding	3,625 ft^2 (134 cy)	Aroclor 1254	1.9	0.066	3	5.0E-05	No	S120 S121 S122 S123 S124 S125 S126 S136 S137	3,625 ft^2 (134 cy)
		South Transformer Area	9 ft^2 (0.3 cy)	Aroclor 1254 Lead	26 4,210	0.066 400	19	4.00E-04	Yes	S128 S129 S130	9 ft^2 (0.3 cy)
		North Transformer Area	9 ft^2 (0.3 cy)	Aroclor 1254 Lead	1.5 3,080	0.066 400	1	2.0E-05	Yes	S131 S132 S133	9 ft^2 (0.3 cy)

(1) Source: Operable Unit 3 Remedial Investigation Report - Final (December 1996).

(2) Source: Operable Unit 3 Focused Feasibility Study Report (January 1997).

Note: Under the selected remeby, all areas of MARBO Laundry containing impacted soils exceeding screening criteria will be excavated and removed from the site. Since all impacted soils exceeding screening criteria will be removed, it is anticipated that residual risks will be less than the cancer risk criterion of $1.0x10^{-6}$ and non-cancer HI of 1.0.

TABLE B.2-1

ASSUMPTIONS AND UNCERTAINTIES: THEIR POSSIBLE EFFECTS ON RISKS
SITE 20 - WASTE PILE 7

Assumption/Uncertainty	May Over-Estimate Risk	May Under-Estimate Risk	May Over- or Under-Estimate Risk
HAZARD IDENTIFICATION			
Some discrete source areas at this site (the surface drum area and the soil/trash mound) are represented by only one sample, which was collected in order to locate highest concentrations of constituents.			✓
EXPOSURE ASSESSMENT			
USEPA Region IX (1995) PRGs assume that the following soil pathways are complete: ingestion, dermal contact, and inhalation. The only receptor identified in the conceptual site model with inhalation as a complete pathway is a construction worker.	✓		
In addition to surface soil samples, subsurface samples were evaluated in the industrial scenario. The only non-residential receptor identified in the conceptual site model with potential to contact subsurface soil is a construction worker.			✓
Summary statistics calculated for constituents of potential concern assume 1/2 the limit of detection (LOD) for non-detects. Non-detects are within the range of 0 - LOD.			✓
The 95% upper confidence limit (UCL) or maximum detection is assumed to represent the concentration to which most people may be exposed.	✓		
Media intake is assumed to be constant over time and representative of the exposed population; however, all exposure factors tend to be upper-bound estimates.	✓		
The assessment assumed 100% bioavailability of all constituents for the oral route of exposure.	✓		
The noncancer-based residential PRGs for soil are calculated using the exposure factors for a child. This would overestimate risks for an older receptor.	✓		
TOXICITY ASSESSMENT			
USEPA Region IX (1995) PRGs incorporate toxicity criteria obtained from IRIS through July 1995 and from HEAST through November 1994; therefore, toxicity criteria used in this assessment may not be current.			✓
Both cancer and noncancer endpoints are calculated for all constituents using the integrated PRG values (USEPA Region IX, 1995).	✓		

TABLE B.2-1

ASSUMPTIONS AND UNCERTAINTIES: THEIR POSSIBLE EFFECTS ON RISKS
SITE 20 - WASTE PILE 7
(Page 2 of 2)

Assumption/Uncertainty	May Over-Estimate Risk	May Under-Estimate Risk	May Over- or Under-Estimate Risk
Not all cancer slope factors (CSFs) or reference doses (RfDs) represent the same degree of certainty.			✓
Toxicity criteria are not available for the dermal route of exposure. Dermal toxicity values are route-to-route extrapolated from oral values.			✓
The oral CSF for Aroclor 1260 incorporated into this assessment is 7.7 mg/kg/day^{-1}. This value has recently been revised to 2.0 mg/kg/day^{-1}.	✓		
The oral CSF for beryllium is based on a study (Schroeder and Mitchener, 1975) in which the lowest dose did not have a statistically different tumor incidence than the control.	✓		
The critical study for deriving the inhalation unit risk of beryllium did not account for smoking (Wagoner et al., 1980).	✓		
The oral RfD for beryllium is based on a no observed adverse effect level (NOAEL) that is the highest experimental dose. The NOAEL could be significantly higher.	✓		
RISK CHARACTERIZATION			
The calculated exposure point concentrations for aluminum, antimony, and arsenic were less than the background values. Inclusion of these constituents in the assessment overestimates risk associated with past waste disposal practices.	✓		
Cancer risks and hazard indices associated with multiple constituent exposure is assumed to be additive. Risks and hazards may, in fact, be antagonistic (less than additive) or synergistic (more than additive) with other constituents.			✓
All constituent-specific hazard quotients are summed regardless of target organ.	✓		
Risks and hazards associated with multiple exposure pathways are combined.	✓		

TABLE B.2-2

ASSUMPTIONS AND UNCERTAINTIES: THEIR POSSIBLE EFFECTS ON RISKS
SITE 22 - WASTE PILE 6
(Page 1 of 2)

Assumption/Uncertainty	May Over-Estimate Risk	May Under-Estimate Risk	May Over- or Under-Estimate Risk
HAZARD IDENTIFICATION			
Most of the discrete source areas at this site (with the exception of the two trenches) are represented by only one sample, which was collected in order to locate highest concentrations of constituents.			✓
EXPOSURE ASSESSMENT			
USEPA Region IX (1995) PRGs assume that the following soil pathways are complete: ingestion, dermal contact, and inhalation. The only receptor identified in the conceptual site model with inhalation as a complete pathway is a construction worker.	✓		
In addition to surface soil samples, subsurface samples were evaluated in the industrial scenario. The only non-residential receptor identified in the conceptual site model with potential to contact subsurface soil is a construction worker.			✓
Summary statistics calculated for constituents of potential concern assume 1/2 the limit of detection (LOD) for non-detects. Non-detects are within the range of 0 - LOD.			✓
The 95% upper confidence limit (UCL) or maximum detection is assumed to represent the concentration to which most people may be exposed.	✓		
Media intake is assumed to be constant over time and representative of the exposed population; however, all exposure factors tend to be upper-bound estimates.	✓		
The assessment assumed 100% bioavailability of all constituents for the oral route of exposure.	✓		
The noncancer-based residential PRGs for soil are calculated using the exposure factors for a child. This would overestimate risks for an older receptor.	✓		
TOXICITY ASSESSMENT			
USEPA Region IX (1995) PRGs incorporate toxicity criteria obtained from IRIS through July 1995 and from HEAST through November 1994; therefore, toxicity criteria used in this assessment may not be current.			✓

TABLE B.2-2

ASSUMPTIONS AND UNCERTAINTIES: THEIR POSSIBLE EFFECTS ON RISKS
SITE 22 - WASTE PILE 6

Assumption/Uncertainty	May Over-Estimate Risk	May Under-Estimate Risk	May Over- or Under-Estimate Risk
Both cancer and noncancer endpoints are calculated for all constituents using the integrated PRG values (USEPA Region IX, 1995).	✓		
Not all cancer slope factors (CSFs) or reference doses (RfDs) represent the same degree of certainty.			✓
Toxicity criteria are not available for the dermal route of exposure. Dermal toxicity values are route-to-route extrapolated from oral values.			✓
The oral CSF for beryllium is based on a study (Schroeder and Mitchener, 1975) in which the lowest dose did not have a statistically different tumor incidence than the control.	✓		
The critical study for deriving the inhalation unit risk of beryllium did not account for smoking (Wagoner et al., 1980).	✓		
The oral RfD for beryllium is based on a no observed adverse effect level (NOAEL) that is the highest experimental dose. The NOAEL could be significantly higher.	✓		
RISK CHARACTERIZATION			
Cancer risks and hazard indices associated with multiple constituent exposure is assumed to be additive. Risks and hazards may, in fact, be antagonistic (less than additive) or synergistic (more than additive) with other constituents.			✓
All constituent-specific hazard quotients are summed regardless of target organ.	✓		
Risks and hazards associated with multiple exposure pathways are combined.	✓		

TABLE B.2-3

ASSUMPTIONS AND UNCERTAINTIES: THEIR POSSIBLE EFFECTS ON RISKS
SITE 24 - LANDFILL 29
(Page 1 of 2)

Assumption/Uncertainty	May Over-Estimate Risk	May Under-Estimate Risk	May Over- or Under-Estimate Risk
HAZARD IDENTIFICATION			
The metal debris area is represented by only one sample, which was collected in order to locate the highest concentrations of constituents.			✓
EXPOSURE ASSESSMENT			
USEPA Region IX (1995) PRGs assume that the following soil pathways are complete: ingestion, dermal contact, and inhalation. The only receptor identified in the conceptual site model with inhalation as a complete pathway is a construction worker.	✓		
In addition to surface soil samples, subsurface samples were evaluated in the industrial scenario. The only non-residential receptor identified in the conceptual site model with potential to contact subsurface soil is a construction worker.			✓
Summary statistics calculated for constituents of potential concern assume 1/2 the limit of detection (LOD) for non-detects. Non-detects are within the range of 0 - LOD.			✓
The 95% upper confidence limit (UCL) or maximum detection is assumed to represent the concentration to which most people may be exposed.	✓		
Media intake is assumed to be constant over time and representative of the exposed population; however, all exposure factors tend to be upper-bound estimates.	✓		
The assessment assumed 100% bioavailability of all constituents for the oral route of exposure.	✓		
The noncancer-based residential PRGs for soil are calculated using the exposure factors for a child. This would overestimate risks for an older receptor.	✓		
TOXICITY ASSESSMENT			
USEPA Region IX (1995) PRGs incorporate toxicity criteria obtained from IRIS through July 1995 and from HEAST through November 1994; therefore, toxicity criteria used in this assessment may not be current.			✓

TABLE B.2-3

ASSUMPTIONS AND UNCERTAINTIES: THEIR POSSIBLE EFFECTS ON RISKS
SITE 24 - LANDFILL 29

Assumption/Uncertainty	May Over-Estimate Risk	May Under-Estimate Risk	May Over- or Under-Estimate Risk
Both cancer and noncancer endpoints are calculated for all constituents using the integrated PRG values (USEPA Region IX, 1995).	✓		
Not all cancer slope factors (CSFs) or reference doses (RfDs) represent the same degree of certainty.			✓
Toxicity criteria are not available for the dermal route of exposure. Dermal toxicity values are route-to-route extrapolated from oral values.			✓
RISK CHARACTERIZATION			
The calculated exposure point concentration for arsenic in the landfill area was less than the background value. Inclusion of this constituent in the assessment overestimates risk associated with past waste disposal practices.	✓		
Cancer risks and hazard indices associated with multiple constituent exposure is assumed to be additive. Risks and hazards may, in fact, be antagonistic (less than additive) or synergistic (more than additive) with other constituents.			✓
All constituent-specific hazard quotients are summed regardless of target organ.	✓		
Risks and hazards associated with multiple exposure pathways are combined.	✓		

TABLE B.2-4

ASSUMPTIONS AND UNCERTAINTIES: THEIR POSSIBLE EFFECTS ON RISKS
MARBO LAUNDRY
(Page 1 of 2)

Assumption/Uncertainty	May Over-Estimate Risk	May Under-Estimate Risk	May Over- or Under-Estimate Risk
HAZARD IDENTIFICATION			
Both transformer areas at this site are represented by only three samples, which were collected in an attempt to locate the highest concentrations of constituents.			✓
EXPOSURE ASSESSMENT			
USEPA Region IX (1995) PRGs assume that the following soil pathways are complete: ingestion, dermal contact, and inhalation. The only receptor identified in the conceptual site model with inhalation as a complete pathway is a construction worker.	✓		
Summary statistics calculated for constituents of potential concern assume 1/2 the limit of detection (LOD) for non-detects. Non-detects are within the range of 0 - LOD.			✓
The 95% upper confidence limit (UCL) or maximum detection is assumed to represent the concentration to which most people may be exposed.	✓		
Media intake is assumed to be constant over time and representative of the exposed population; however, all exposure factors tend to be upper-bound estimates.	✓		
The assessment assumed 100% bioavailability of all constituents for the oral route of exposure.	✓		
The noncancer-based residential PRGs for soil are calculated using the exposure factors for a child. This would overestimate risks for an older receptor.	✓		
TOXICITY ASSESSMENT			
USEPA Region IX (1995) PRGs incorporate toxicity criteria obtained from IRIS through July 1995 and from HEAST through November 1994; therefore, toxicity criteria used in this assessment may not be current.			✓
Both cancer and noncancer endpoints are calculated for all constituents using the integrated PRG values (USEPA Region IX, 1995).	✓		
Not all cancer slope factors (CSFs) or reference doses (RfDs) represent the same degree of certainty.			✓

TABLE B.2-4

ASSUMPTIONS AND UNCERTAINTIES: THEIR POSSIBLE EFFECTS ON RISKS
MARBO LAUNDRY
(Page 2 of 2)

Assumption/Uncertainty	May Over-Estimate Risk	May Under-Estimate Risk	May Over- or Under-Estimate Risk
Toxicity criteria are not available for the dermal route of exposure. Dermal toxicity values are route-to-route extrapolated from oral values.			✓
The oral RfD for Aroclor 1254 is based on non-critical health effects such as eye inflammation and nail growth and on immunological changes that are not directly quantifiable to adverse health effects.	✓		
The oral CSF for Aroclor 1254 incorporated into this assessment is 7.7 mg/kg/day^{-1}. This value has recently been revised to 2.0 mg/kg/day^{-1}.	✓		
The oral CSF for beryllium is based on a study (Schroeder and Mitchener, 1975) in which the lowest dose did not have a statistically different tumor incidence than the control.	✓		
The critical study for deriving the inhalation unit risk of beryllium did not account for smoking (Wagoner et al., 1980).	✓		
The oral RfD for beryllium is based on a no observed adverse effect level (NOAEL) that is the highest experimental dose. The NOAEL could be significantly higher.	✓		
RISK CHARACTERIZATION			
The calculated exposure point concentrations for aluminum, beryllium, and chromium were less than the background values. Inclusion of these constituents in the assessment overestimates risk associated with past waste disposal practices.	✓		
Cancer risks and hazard indices associated with multiple constituent exposure is assumed to be additive. Risks and hazards may, in fact, be antagonistic (less than additive) or synergistic (more than additive) with other constituents.			✓
All constituent-specific hazard quotients are summed regardless of target organ.	✓		
Risks and hazards associated with multiple exposure pathways are combined.	✓		

TABLE B.2-5

ASSUMPTIONS AND UNCERTAINTIES: THEIR POSSIBLE EFFECTS ON RISK ESTIMATES
OU2 (GROUNDWATER)

Assumption/Uncertainty	May Over-Estimate Risk	May Under-Estimate Risk	May Over- or Under-Estimate Risk
HAZARD IDENTIFICATION			
Eliminating constituents whose maxima are within an order of magnitude of their PRGs may miss additive risks or hazards over 10^{-6} or one, respectively.		✓	
EXPOSURE ASSESSMENT			
Exposure to constituent concentrations from deep in the aquifer is highly unlikely.	✓		
The maximum is assumed to represent the concentration to which most people may be exposed.	✓		
Concentration of constituents of potential concern in groundwater is assumed to remain constant over residential receptors' entire 30-year exposure duration.	✓		
Use of production well data rather than tap water for exposure point concentrations of VOCs.	✓		
Estimated data are included in quantitative risk assessment.			✓
Dermal exposure pathway is excluded from PRG calculations for tap water.		✓	
Media intake is assumed to be constant over time and representative of the exposed population.	✓		
Assumed standard assumption for body weight, exposure period and frequency, and life expectancy.			✓
Conservative model used to evaluate volatile emissions to air.	✓		
TOXICITY ASSESSMENT			
Carcinogenicity of tetrachloroethene and trichloroethene in humans is uncertain. Only provisional CSFs are available for these constituents.	✓		
Toxicity criteria were derived from animal studies.	✓		
The cancer potencies used are 95% UCLs derived from the linearized multistage model.	✓		
Not all carcinogenic potencies or reference doses represent the same degree of certainty.			✓

TABLE B.2-5

ASSUMPTIONS AND UNCERTAINTIES: THEIR POSSIBLE EFFECTS ON RISK ESTIMATES
OU2 (GROUNDWATER)

Assumption/Uncertainty	May Over-Estimate Risk	May Under-Estimate Risk	May Over- or Under-Estimate Risk
RISK CHARACTERIZATION			
Risk and hazards associated with multiple chemical exposure were assumed to be additive. Risks and hazards may, in fact, be antagonistic (less than additive) or synergistic (more than additive) with other chemicals.			✓
Risks and hazards associated with multiple exposure pathways combined.	✓		

APPENDIX C

REGULATORY COMMENTS AND RESPONSES

RESPONSES TO USEPA REGION IX COMMENTS
DATED FEBRUARY 11, 1998
MARBO ANNEX OPERABLE UNIT RECORD OF DECISION (R.O.D.)
DRAFT FINAL, DECEMBER 1997

GENERAL COMMENTS

The two references cited throughout these comments are the Interim Final Guidance on Preparing Superfund Decision Documents (EPA, 1989) and EPA's Record of Decision Checklist for Final Source Actions (ROD Checklist).

Comment No. 1: **Soil Disposal**

Under CERCLA, disposal of any soil or debris contaminated with any hazardous substance, pollutant or contaminant off-site will be subject to the Off-Site Disposal Rule (40 CFR 200.440). EPA Region 9 has taken the position that on-site is the area designated in the NPL listing and thus the Off-Site Rule does not apply to the disposal of contaminated soil from one part of Andersen to another area within Andersen. However, such disposal may trigger RCRA as an ARAR. Disposal of soil not contaminated with any hazardous substance, pollutant or contaminant may trigger the RCRA solid waste disposal requirements as ARARs. The ARARs discussion should more fully discuss the applicability to inapplicability of the solid waste disposal requirements to the selected remedy and, to the extent relevant, explain why the hazardous waste is not RCRA hazardous waste.

The ROD should also clarify whether the "non-hazardous" soil that will be disposed of on-site is merely non-RCRA-hazardous waste or also non-CERCLA-hazardous waste. The modifier "non-hazardous" should not be used lightly.

Response: The soil and debris which is proposed for disposal at the AAFB landfill is material which will not exhibit RCRA hazardous waste characteristics under 40 CFR 261.20 through 261.24 and is not listed RCRA hazardous waste under 40 CFR 261.30 through 261.33. CERCLA 40 CFR 302.3 defers to RCRA for hazardous waste classification, thus the waste would also not be considered hazardous under CERCLA (as defined by RCRA). The classification of soil and debris as RCRA hazardous or non-

hazardous is discussed in the text of the R.O.D. and presently included as an ARAR in the R.O.D.

The soil and debris which is proposed for disposal at the AAFB Main Base landfill is not a RCRA hazardous waste, but will be solid waste. The Andersen AFB landfill meets the Guam EPA solid waste disposal requirements. Additionally, construction activities are in progress at the landfill to meet RCRA Subtitle D requirements.

For clarification and public record, it is assumed that the Off-Site rule referenced as 40 CFR 200.440 is 40 CFR 300.440.

Comment No. 2: **The discussion concerning public meetings to inform the community of "potential risks" should be expanded to identify briefly the potential risks.**

Response: This is discussed more fully in Section 1.4.

Comment No. 3: **Deed Restrictions**

The ROD needs to identify exactly what deed restrictions will be placed on the site(s) and explain how and when such deed restrictions will be executed.

At page 3-10, what will trigger the land use restrictions pertaining to future locations of water wells? The ROD says"...restrictions on the property deeds (if necessary) pertaining to..." If this is a contingency measure, what is the trigger? Why is this contingent?

Response: Deed restrictions apply to Waste Pile 7 as one of the soil alternatives, as well as to the selected groundwater alternative. The intent of the soil cover at Waste Pile 7 is to eliminate or mitigate the exposure pathway to soils, which slightly exceed the risk management range of $1x10^{-6}$ to $1x10^{-4}$ under a residential scenario. The deed restrictions will restrict the future use of Waste Pile 7 to activities which are non-intrusive to the soil cover, as noted in the OU 3 Focused Feasibility Study. This does not preclude activities which are non-intrusive; some examples may include a maintenance yard or storage area. The deed restrictions will apply during transfer of ownership, and will apply and be included in the deed as a land use limitation.

Due to the nature of Guam's aquifer as a sole source aquifer, production well installation is closely monitored by the Guam EPA through Guam's Groundwater Protection Zone program and strict permitting requirements. Guam EPA's "Guam Wellhead Protection Program" (GWP) (GEPA: March 4, 1993) outlines the requirements and permitting necessary prior to the installation of new wells (Chp VIIB), as well as the institutional mechanisms for implementation (Chp IIIA). As GEPA is part of this CERCLA process, and is also the implementor of the GWP program, transfer of groundwater quality information to GEPA's GWP Zone map will be easily facilitated to safeguard future use of the aquifer.

Presuming the cited page is 3-19, the "if necessary" refers to those properties affected by TCE/PCE where restrictions would be necessary. Many of the detections at the MARBO Annex are below MCLs and below 1 µg/l, thus property restrictions may not apply. This has been removed from the text.

Comment No. 4: **In Section 1.4, *DESCRIPTION OF THE SELECTED REMEDY*, page 1-2:**

This section does not seem to include an explanation of how this response action (remedy) fits into the overall site cleanup strategy (EPA, 1989). It is suggested that an introductory explanation be included to put the proposed remedies for soil and groundwater at the MARBO Annex into context with the overall plan for cleanup at the Andersen AFB NPL site.

Response: An introductory explanation has been added to Section 1.4.

Comment No. 5: **In *Section 1.4.4, Groundwater*, page 1-4:**

This section does not include a statement as to how the selected response action does or does not address the principal threat(s) posted by the site (EPA, 1989, page 6-7). It is suggested that a statement be included to address this requirement at the beginning of this section.

Response: Presuming the cited section is actually 1.4.2, a statement pertaining the principal threats has been added to Section 1.4.2.

Comment No. 6: **In *Section 1.5, STATUTORY DETERMINATIONS* page 1-4:**

This section should include a statement explaining why the statutory preference for treatment (TMV reduction) was not

employed (EPA, 1989, pages 6-7 and 6-8; e.g., substantial and disproportionate benefit analysis) in selecting the remedies for soil and groundwater at the MARBO Annex site. Additionally, per the EPA "ROD Checklist", the text should include the following standard language for the selected soil remedies: "However, because treatment of the principle threats of the site was found to be practicable, this remedy does not satisfy the statutory preference for treatment as a principle element." Since Hazardous substances will remain on-site above health-risk levels, per the EPA "ROD Checklist", the ROD should include the following standard language, "Because the remedies will result in hazardous substances remaining on-site above health-based levels, a review will be conducted within five years after commencement of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment."

Response: Per the EPA ROD checklist, these suggestions have been incorporated in to Section 1.5.

Comment No. 7: **In *Section 2.3, SITE HISTORY AND ENFORCEMENT ACTIVITIES*, page 2-21 through 2-24:**

This section did not contain a "...history of activities at the site that have led to the current problems..." (EPA, 1989, page 6-11), though this information was presented in *Section 2.1*. Please add a sentence in Section 2.3 that refers the reader to Section 2.1 for a history of each of the sites.

Response: A reference sentence has been added to Section 2.3.

Comment No. 8: **In *Section 2.5, SCOPE AND ROLE OF OPERABLE UNIT WITHIN THE SITE STRATEGY,* page 2-26:**

This section did not seem to "...focus on how the response actions fit into the overall strategy for addressing the principal threat(s) posed by conditions at the site" (EPA, 1989, page 6-13). Perhaps a description could be added as a paragraph at the end of this section. Additionally, per the EPA "ROD Checklist", the text should more explicitly "describe whether or not the action will address any of the principle or low level threats posed by conditions at the site."

Response: A paragraph on how the response actions address the principal threat(s) has been added to Section 2.5.

Comment No. 9: **In *Section 2.6, SUMMARY OF SITE CHARCTERISTICS*, page 2-27:**

Per the EPA "ROD Checklist", for each site description, please include estimated volumes of contaminated soil. It may be more appropriate to include this information in Section 2.1.

Response: Estimated volumes have been included at the end of each site description in Section 2.6.

Comment No. 10: **In *Section 2.7, SUMMARY OF SITE RISKS*, page 2-38, and *Section 3.3 SUMMARY OF SITE RISK*, page 4-14:**

These sections do not seem to contain a summary of toxicity assessment information such as exposure frequency and duration assumptions, cancer potency factors for contaminants of concern that are carcinogens, and reference doses for the contaminants of concern that have noncarcinogenic effects (EPA, 1989, pages 6-16 through 6-18). It is suggested that this information from the baseline risk assessment be summarized here. Also, per the EPA "ROD Checklist", please indicate the source of toxicity information used to calculate risks (e.g., cancer potency factor, reference dose) and the risk model from which the risk value: were derived (e.g., IRIS, HEAST, ECAO-Cincinnati). Additionally, per the EPA "ROD" Checklist", a description of significant sources of uncertainty in the risk assessment should be summarized. Finally, these sections should include the following standard language per the EPA "ROD" Checklist". "Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response actions selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or, the environment." an imminent and substantial endangerment to public health, welfare, or, the environment."

Response: Site risks were calculated using the screening risk assessment approach outlined in USEPA's *Region IX Preliminary Remediation Goals (PRGs) Second Half 1995* (USEPA, 1995). Based on this approach, site-specific exposure point concentrations (EPCs) are compared directly to Region IX PRGs. The exposure assumptions

and toxicity assessment information, including cancer potency factors and non-cancer reference doses, used in the development of Region IX PRGs are documented in USEPA (1995). Commensurate with the OU 3 FFS, a copy of the *Region IX Preliminary Remediation Goals (PRGs) Second Half 1995* (USEPA, 1995) will be included in the ROD as Appendix A.

General discussions of the uncertainties in the human health risk assessments for soil and groundwater will be included in Section 2.7 and Section 3.3, respectively. In addition, more detailed, tabulated summaries of site-specific sources of uncertainty will included in Appendix B.

The following statement will be included in Section 2.7 of the ROD, "Based on the potential risks associated with Sites 20, 22, 24, and 38, actual or threatened releases of hazardous substances from these sites, if not addressed by implementing the response actions selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment." In addition, the following statement will be included in Section 3.3 of the ROD, "Based on the results of the human health risk assessment for groundwater, actual or threatened releases of hazardous substances from the site, if not addressed by implementing the response actions selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment."

Comment No. 11: **In *Section 2.8, DESCRIPTION OF ALTERNATIVES*, page 2-42:**

Please identify the quantity of waste to be covered or excavated in this section, per the EPA "ROD Checklist." This section should also refer to Section 2.9 for a description of estimated present worth, capital, and O&M costs.

Response: Volumes and area applicability have been added to Section 2.8 and costs have been referenced to Section 2.10.

Comment No. 12: **In *Section 2.9, SUMMARY OF COMPARATIVE ANALYSIS ALTERNATIVES*, page 2-46 and *Section 3.5, COMPARATIVE ANALYSIS OF ALTERNATIVES SUMMARY*, page 3-22:**

EPA guidance (EPA, 1989, page 6-25) suggests that "...under each criterion, the alternative that performs best in that

category is discussed first, with the other options discussed in sequence from most to least advantageous."

Response: The modification of discussing the best to worst performing alternative has been made in each criteria section.

Comment No. 13: **In *Section 2.9.4, Long-Term Effectiveness and Permanence*, page 2-53:**

Per the EPA "ROD Checklist", please address the residual risk of each alternative, assuming the alternative is implemented. At a minimum indicate if the remaining risk would be less than 1 x 10-6, between 1 x 10-6 and 1 x 10-4, or greater than 10-4. Please also address the hazard index.

Response: General descriptions of the residual risk (i.e., cancer risk and non-cancer hazard index) associated with each potential alternative will be included in Section 2.9.4. Additionally, site-specific descriptions of the residual cancer risk and non-cancer hazard index associated with the selected remedial alternative (i.e., soil cover or soil removal) will be incorporated into Section 2.10 (refer to the Response to General Comment No. 16).

Comment No. 14: **In *Section 2.9.7, Cost*, page 2-56:**

Per the EPA "ROD Checklist", please include the capital and O&M costs for each alternative evaluated. Table 2-6 only provides present worth costs.

Response: Costs have been broken down in to capital and O&M.

Comment No. 15: **In *Section 2.9.8, State/Territory Acceptance*, page 2-57:**

Per the EPA "ROD Checklist", since the Air Force is the lead agency, this section should address EPA's acceptance of the selected remedy.

Response: EPA's acceptance of the selected remedy has been added.

Comment No. 16: **In *Section 2.10, THE SELECTED REMEDY*, page 2-57 to 2-63:**

This section incorrectly refers to the selected remedy as the preferred alternative. For example, on page 2-58, the text states "Soil Cover is the preferred alternative." Similar

language exists for other soil sites. Please change "preferred alternative" to "selected remedy." Also, per the EPA "ROD Checklist", please provide capital and present worth costs for the selected remedy. Additionally, although contaminated soil will not be treated, this section should indicate, for each site, the remaining risk levels corresponding to the selected remedy. See EPA "ROD Checklist", and similar comment above on Section 2.9.4. Finally, to address "point of compliance" and "residual contamination" in the EPA "ROD Checklist", the selected remedy should explain why long term groundwater compliance monitoring at each site is not a component of the selected remedies.

Response:

The term "preferred alternative" has been changed to "selected remedy" and costs have been broken down in to capital and O&M.

For each site, a description of the residual cancer risk and non-cancer hazard index associated with the selected remedial alternative (i.e., soil cover or soil removal) will be incorporated into Section 2.10. For Site 20 (Waste Pile 7), a qualitative evaluation of residual risk will be presented since the selected remedy (i.e., soil cover) will result in the elimination of exposure pathways, as long as the soil cover remains intact. A qualitative evaluation of residual risk will also be presented for Site 38 (MARBO Laundry) since all known contamination associated with the site will be removed under the selected remedy (i.e., soil removal). For Site 22 (Waste Pile 6) and Site 24 (Landfill 29), where residual contaminants will be left in place under the selected remedy (i.e., soil removal), quantitative evaluations of residual risk will be presented. (Calculations indicate that residual risk is less than $1x10^{-6}$ for each of the selected remedies.)

Long term groundwater compliance monitoring is part of the overall AAFB groundwater monitoring program, including the MARBO Annex. For Waste Pile 7, where soil removal is not a selected alternative, site specific groundwater monitoring wells (IRP-10, -15, and –16) will continue to be monitored for contaminants detected at Waste Pile 7. For those sites where soil removal is the selected alternative, any potential impact on groundwater via precipitation leachate from the surface has been removed. In both cases, the monitoring wells closest to each site are being monitored as part of the Long Term Monitoring Plan.

Comment No. 17: **In *Section 2.11.4, Utilization of Permanent Solution...*, page 2-64:**

Per the EPA "ROD Checklist", please describe the role of the State and community acceptance considerations and provide a statement that the selected remedies do not meet the statutory requirements to utilize permanent solutions and treatment technologies because treatment if impractical.

Response: The State (Territory) and community acceptance considerations have been added, as well as discussion on permanent solutions and treatment technologies.

Comment No. 18: **In *Section 3.4, THE DESCRIPTION OF ALTERNATIVES*, page 3-17 to 3-21:**

Section 3.4.2 (Natural Attenuation), first sentence states, "This alternative utilizes Natural Attenuation of TCE/PCE in the aquifer to achieve remediation goals." It would be useful in this section, and in other appropriate sections, to explicitly define "remediation goals" (e.g., to reduce TCE and PCE concentrations in groundwater to below MCLs).

Response: TCE and PCE remediation goals have been added in the necessary sections.

Comment No. 19: **In *Section 3.6, THE SELECTED REMEDY*, page 2-33 to 3-34:**

The description of the selected remedy, Natural Attenuation and Wellhead Treatment, does not define an end point or "point of compliance." For example, the text could indicate that this remedy will continue until long term groundwater monitoring indicates that TCE and PCE concentrations are consistency below MCLs. Additionally, the text could indicate that each five year review would: 1) determine if the remedy is still effective, 2) determine if the remedy has achieved its goals, and thus, can be discontinued.

Response: A paragraph has been added indicating that the remedy will continue until long term monitoring indicates that TCE and PCE concentrations are consistently below MCLs, as well as the suggested five year criteria. Additionally, AAFB will conduct a review of it's long term groundwater monitoring plan every two years.

SPECIFIC COMMENTS

Comment No. 1: **In *TABLE OF CONTENTS, LIST OF ACRONYMS AND ABBREVIATIONS*, pages v and vi:**

The definitions should have the same capitalizations as they would when they appear in the text (e.g., below ground surface, polycyclic aromatic hydrocarbon, volatile organic compound, etc.)

Response: This has been corrected.

Comment No. 2: **In *Section 1.3*:**

The language is rather cumbersome and vague. Perhaps something like the following would be more clear:

"Risks to human health and the environment were evaluated for groundwater near MARBO and at six surface sites within MARBO. No risk was found at Waste Pile 5 and the War Dog Borrow Pit, so no further action is planned for these two sites. Current risks associated with soil exceed acceptable risk levels at Waste Pile 6, Waste Pile 7, Landfill 29, and the MARBO Laundry, thus remedial alternatives were evaluated for these four sites."

"Current risk associated with contaminants in groundwater..." The rest of this section is O.K.

Response: This language has been added.

Comment No. 3: **In *Section 1.4.1, Soil*, page 1-2:**

It is suggested that the contaminants of concern for which the remedy is to be implemented be mentioned so the reader understands what in the soil is of concern.

Response: The contaminants of concern have been added.

Comment No. 4: **In *Section 1.4.1, Soil,* page 1-3, first bullet:**

For completeness, backfilling and compacting the excavations with clean fill should be mentioned as part of the soil remedial action.

Response: Backfilling and compacting is part of the remedy and has been mentioned.

Comment No. 5: **In *Section 1.5, STATUTORY DETERMINATIONS*, page 1-4, sixth line:**

Please include an explanation of why the statutory preference for remedies that employs treatment as a principal element was not met.

Response: As noted in general comment #6, this discussion has been added to the text.

Comment No. 6: **In *Section 2.1, SITE NAME, LOCATION, AND DESCRPTION*, page 2-1, first paragraph, lines 3 and 4:**

Please include the '°' symbol in the latitude and longitude citations.

Response: The degree symbol has been added.

Comment No. 7: **In the same section and page, second paragraph, last line:**

Because the North and Northwest Fields are mentioned in the text as points of reference, it would be helpful to show their locations in Figure 2-1.

Response: These locations have been added.

Comment No. 8: **In *Section 2.1.2, Site 22* (Waste Pile 6), please identify the vertical extent of contamination.**

Response: The vertical extent of contamination has been added.

Comment No. 9: **In Sections 2.1.4 and 2.1.5, please change the phrase "Based on a risk evaluation of soil analytical data, a health risk was not identified..." to "No health risk was identified at Waste Pile 5 (or War Dog Borrow Pit), based on a risk evaluation of soil analytical data."**

It is suggested that the contaminants of concern for which the remedy is to be implemented be mentioned so the reader understands what in the soil is of concern.

Response: The health risk evaluation terminology has been added as suggested. As also noted in General Comment Number 3, contaminants of concern are mentioned.

Comment No. 10: **On the top of page 2-5, please delete "in addition to the 2.44 acre landfill," and begin that sentence with "The Surface Drum Area..."**

Response: This modification has been made.

Comment No. 11: **In *Section 2.1.5, Site 37* (War Dog Borrow Pit), please include a detailed size map to be consistent with the other site descriptions.**

Response: Figures for the ROD were obtained from the OU 3 FFS. The decision was made not to include figures for the War Dog Borrow Pit and Waste Pile 5 primarily because of a lack of detail pertinent to the ROD, and because both of these sites are no further action.

Comment No. 12: **In *Section 2.2.1, Geology,* first paragraph, second line: Is "tests" the correct word in the phrase' . . . composed of formanifers tests."**

Response: Yes, tests is the correct term.

Comment No. 13: **In *2.3, SITE HISTORY AND ENFORCEMENT ACTIONS,* page 2-24, second paragraph, fifth line:**

We suggest that "either" be changed to "any."

Response: This modification has been made.

Comment No. 14: **In *Section 2.6.1, Contaminant Screening Process,* page 2-27, sixth line:**

Spell out Preliminary Remediation Goals (PRGs) (in first use).

Response: This modification has been made.

Comment No. 15: **In *Section 2.8.4, Soil Removal (Alternative OU3-D)*, page 2-45, last paragraph:**

As Land Disposal Restrictions are potentially applicable, it might helpful to mention that this ARAR could affect the disposition of some of the soil and debris removed.

Response: This addition has been made.

Comment No. 16: **In Section 2.9.4, Long-Term Effectiveness and Permanence, page 2-54, third paragraph:**

Under "Soil Cover," it should be noted that this alternative restricts future uses of the applicable sites in that soil intrusive activities are not to be permitted (Institutional Control) and hence economic values of such restricted sites may be lessened compared to a "Soil Removal" alternative.

Response: This addition has been made.

Comment No. 17: **In *Section 2.10.1, Site 20 (Waste Pile 7)*, page 2-57, second line:**

Please clarify the reason "Soil removal was not deemed applicable . . . "; e.g., cost (versus soil cover) exceeds benefit (reduced risk of exposure).

Response: The level of effort and cost associated with soil removal outweighed the benefit of risk reduction at Waste Pile 7. This has been added to the text.

Comment No. 18: **On page 2-58: TSCA regulates PCBs at concentrations of [≥] 50 ppm. Did Andersen look at the *PCB Spill Policy* and *the EPA Guidance on Remedial Action for Superfund Sites with PCB Contamination?* Is leaving PCB contamination on/in the ground a "PCB spill" or "PCB disposal."**

Response: The document "A Guide on Remedial Actions at Superfund Sites With PCB Contamination" (EPA, August 1990) was referenced for this comment. Based on a review of this document, the R.O.D. appears to be consistent with this guidance. By definition, the PCB spill policy 40CFR 761.120 addresses PCB spills which occurred after May 4, 1987. The two sites where PCBs were detected in the soil became inactive prior to 1987. Additionally, 40CFR 761.3 defines a "disposal" as "...spills, leaks and other

uncontrolled discharges of PCBs...". Given these criteria, the PCB contamination detected at Waste Pile 7 and the former MARBO Laundry appears to be a disposal.

Comment No. 19: **Page 2-28 and page 2-58: Are the pesticides in the soil at Waste Pile 7 from normal application. Is leaving the pesticides in the ground "disposal" under FIFRA? Please discuss the ARAR implications a little more fully on page 2-58.**

Response: The highest concentrations of pesticides were detected in surface soil samples from Waste Pile 7, indicating that this may have been due to surface application. However, there were pesticides detected in subsurface soil samples as well. Also, the OU 3 RI indicates that debris and disposal material at Waste Pile 7 came from a variety of sources. Thus, it is possible that some of the pesticides are from normal application and some are from disposal, but this is speculative.

Based on a review of the pesticide regulations, EPA regulates pesticides under FIFRA, which regulates the sale, distribution and use of pesticides, and the Federal Food, Drug and Cosmetic Act (FFDCA) which regulates, among other things, pesticide residues in food and feed. As FIFRA is a licensing statute, there were no references found which addressed whether leaving pesticides in the ground is considered "disposal". Additionally, there were no pesticide containers or product containers discovered at Waste Pile 7, which would have otherwise triggered FIFRA as a potential ARAR.

These points have been added to Section 2.10.1.

Comment No. 20: **In Table 2-6, page 2-59:**

Footnote "b" should be added to the Pertinent ARARs Compliance column for the Institutional Control and Soil Cover Alternatives for Site 22, Site 24, and Site 38. Under Site 22, Total Cost column, "$0,600: should be "$30,600."

Response: These corrections have been made to Table 2-6.

Comment No. 21: **In *Section 2.10.4, Site 38 (MARBO Laundry)*, page 2-63, second paragraph, third sentence:**

This sentence conflicts with the PCB information presented in Tables 2-2, 2-3, and 2-5 (ARARs). The means of disposal (and

costs) of PCB-containing soil is not discussed. Please discuss the TSCA regulations governing PCB cleanup and disposal and evaluate whether they are ARARs at the MARBO laundry.

Response: This sentence does indeed conflict with analytical data and previous tables. The paragraph was intended to discuss TSCA as an ARAR, consistent with previous tables. This correction has been made and TSCA is discussed as a pertinent ARAR for transportation and disposal of the soil and debris contaminated with PCBs.

Comment No. 22: **In Figure 3-2:**

The locations of wells M-6 and D-2 are slightly different than in the other figures in this sections.

Response: This correction has been made.

Comment No. 23: **In *Section 3.3.1, Human Health Risk,* pages 3-14 and 3-15.**

The significance of the 4.34 (Table 3-4) Hazard Index for well IRP-31 (D) was not addressed.

Response: The following statement will be included in Section 3.3.1: "Monitoring wells where COCs were detected are generally within EPA's risk management range of 1×10^{-6} to 1×10^{-4} and below an HI of 1.0, with the exception of IRP-31. Monitoring well IRP-31 exceeds an HI of 1.0, however this is a deep well with a high chloride content and not meant for consumption. In addition, land use restrictions will be implemented to regulate the installation of new wells, and groundwater monitoring is included as a component to overall protection of human health and the environment."

Comment No. 24: **In *Section 3.5.5, Reduction of Toxicity, Mobility, or Volume Through Treatment,* page 3-30:**

No discussion is included on the potential for an increase in toxicity through natural biodegration of TCE and PCE to more toxic COCs such as 1,2-DCE and vinyl chloride (through this is apparently not occurring at any measurable rate).

Response: This was not mentioned as it was not considered to be of concern. It has been added, however, under the "Natural Attenuation" scenario for completeness.

Comment No. 25: **On Page 4-3:**

The AAFB response to the comments by Senator Brown could be more expansive, i.e., responsive. In particular, the response might attempt to address the issue of the capacity for future use or development at the site, what exactly deed restrictions will mean, and what type of use will be safe with the cap.

Response: The response has been modified by removing the last sentence of AAFB's original response and adding the following text:

"Site 20 lies within an abandoned quarry, with an average depth to the base of fill of 10.8 feet bgs, and as such it has limited future land use regardless of whether the waste pile were removed. The restrictions on Waste Pile 7 would additionally limit the use of the property to activities which are non-intrusive in nature, and would be included in the deed during transfer. Intrusive activities would open an exposure pathway and defeat the purpose of the soil cover. Some ideas of non-intrusive activities may include a maintenance yard or storage area."

Comment No. 26: **On page 4-4:**

The response to Ernie Wusstig could also be more expansive.

Response: The following is a response to Mr. Wusstig's first question, to be appended to AAFB's original response.

"There are two areas of concern in the groundwater underlying the MARBO Annex, where concentrations of TCE and/or PCE exceed Federal allowable levels. One is beneath the former MARBO Laundry, where PCE slightly exceeds Federal levels, and the other is across from the Yigo Power Plant, where TCE exceeds Federal levels. Though the PCE underlying the MARBO Laundry is likely a result of military activities, it is unclear where the source of the TCE originated. After approximately ten years of monitoring these areas, the TCE and PCE do not appear to be migrating. Thus, the overall impact on the aquifer is isolated to two small areas representing a very small portion of the groundwater underlying the MARBO Annex.

On a broader, national level, impacts to soil and groundwater from industrial activities were not known to be an issue until the early 1970's. The military has been consistent and pro-active with investigative and remedial activities occurring nationally. Should there have been a situation where an imminent health risk existed, immediate measures would have been taken."

RESPONSES TO GUAM EPA COMMENTS
DATED FEBRUARY 20, 1998
MARBO ANNEX OPERABLE UNIT RECORD OF DECISION (R.O.D.)
DRAFT FINAL, DECEMBER 1997

SPECIFIC COMMENTS

Comment No. 1: **Page 2-11, First Paragraph. Groundwater in the NGL ranges from a calcium - bicarbonate type, through a calcium - sodium - bicarbonate - chloride type, water as the effects of salt water intrusion become more significant. The relative concentrations of magnesium, silica, and nitrate are low in comparison to the major cations and anions in the NGL, and their occurrence and significance should be discussed separately.**

Response: A statement has been added to this section regarding the effect that overpumping would have on elevated chloride concentrations. The relative concentrations of the naturally occurring ions is important and discussed fully in the RI. A sentence has been added referring the reader to Section 4.0 of the OU 2 RI for detailed information pertaining to inorganic water quality conditions.

Comment No. 2: **Page 2-11, Second Paragraph. Concentrations of chloride in basal sections of the NGL have been reported much higher than the 150 mg/L concentration presented in this paragraph.**

Response: Concentrations up to 280 mg/l were detected in IRP-40 during the IRP investigation, and up to 1,100 in IRP-41 (though IRP-41 was due to excessive pumping in an attempt to lower pH). This has been modified in the text.

Comment No. 3: **Page 2-45, Fourth Paragraph. The reference to "RPM" should be "RPMs"**

Response: This correction has been made.

Comment No. 4: **Page 2-57, Section 2.9.9. This section is misleading. Although public participation was extremely low in terms of numbers of people who expressed concerns regarding the Proposed Plan, the comments which were expressed were very significant in terms of their impact on the island.**

In particular, comments were made by Senator Joanne Brown during the RAB prior to the public hearing on the Proposed Plan and during the public hearing itself regarding Waste Pile 7, the connection between soil contamination and groundwater contamination and land use restrictions on federal properties after lease or transfer to GovGuam. The Senator's concerns are significant and most likely represent concerns shared by other community members who may not be as educated in the CERCLA process as the Senator, who is the Co-Chair of the RAB. The Senator's concerns are presented in Section 4-2 of the Draft ROD and should be referenced in all other sections of this document which refer to "Public Comment", or "Public Acceptance", including Section 2.9.9.

Response:

The following statement has been added to Section 2.9.9 and 3.5.9 of the main body of the text:

"Senator Brown noted concern pertaining to the connection between soil contamination at Waste Pile 7 and the groundwater, as well as the land use restrictions that will be applied to Waste Pile 7 after transfer to Gov Guam. The land use restrictions preclude the use of activities that would disrupt the integrity of the soil cover."

Similar to U.S.E.P.A. comment #25, the Andersen Air Force response to Senator Brown's comment has been supplemented to address her primary concern's, including a discussion on the land use restrictions' applicability, and potential future uses of the site. The following text has been added to Section 4.3:

"Site 20 lies within an abandoned quarry, with an average depth to the base of fill of 10.8 feet bgs, and as such it has limited future land use regardless of whether the waste pile were removed. The restrictions on Waste Pile 7 would additionally limit the use of the property to activities which are non-intrusive in nature and would be included in the deed during transfer. Intrusive activities would open an exposure pathway and defeat the purpose of the soil cover. Some ideas of non-intrusive activities may include a maintenance yard or storage area."

Comment No. 5:

Page 2-57, Section 2.10.1, First Paragraph. The last sentence in this paragraph is confusing to the reader and needs to be expanded and more fully explained.

Response:

This sentence has been modified to read more clearly.

Comment No. 6: **Page 3-19, Section 3.4.2, First Paragraph. Chemical analysis of groundwater samples collected from the MARBO OU indicate that daughter products of PCE and TCE degradation are generally absent. This does not suggest effective natural attenuation. Documenting the efficiency of natural attenuation of chlorinated solvents requires an understanding of the ambient redox conditions in the aquifer, the tracking of the presence and disappearance of electron acceptors, the appearance of end products, and other appropriate stoichiometric conditions of the degradation reactions. Please provide evidence which supports the process of TCE and PCE degradation in MARBO groundwater, rather than the dilution process, which may in fact be the controlling process in the documented decreases in the concentration of the contaminants.**

Response: It is stated throughout the OU 2 FFS, Proposed Plan and R.O.D. that the controlling mechanism of attenuation is based on the high rate of groundwater flux through the aquifer. There have been no significant detections of dehalogenated byproducts such as DCE or Vinyl Chloride. This is further supported by the high dissolved oxygen concentrations in the aquifer, whereas dehalogenated byproducts are manifestations of less aerobic, reductive conditions.

Comment No. 7: **Page 3-19, Section 3.4.2, Institutional Controls, Land Use Restrictions. This section should include a provision by which any land leased or transferred to GovGuam on which production wells are installed and become contaminated because of Air Force activities are included in the existing wellhead treatment program. This would apply to properties under which groundwater contamination has not been documented, but becomes contaminated at some time in the future as a result of migration or continued leaching of soil contaminants.**

Response: Evidence suggests that TCE and PCE concentrations in groundwater are decreasing, and that the two areas of concern in the MARBO Annex are isolated and not migrating. Thus a scenario where other wells are potentially impacted by existing groundwater conditions is unlikely. As part of the CERCLA process, the groundwater alternative is evaluated every five years, in part to address situations such as this which may arise.

Soil is not considered a future threat to groundwater. Soil will be removed from three of the four sites which pose a potential health risk, thus removing any potential threat to groundwater. The

contaminants in the soil at the fourth site, Waste Pile 7, are primarily lead and pesticides, which are highly immobile in soil and water. There have been no pesticides or lead detected in the groundwater monitoring wells closest to Waste Pile 7. Based on this, and the fact that these contaminants are immobile, they are not expected to pose a threat to groundwater in the future. As with the soil alternatives however, the CERCLA process requires that the soil alternatives also be re-evaluated for effectiveness every five years. This will be conducted in conjunction with groundwater monitoring results from the Andersen AFB Long Term Groundwater Monitoring Plan every two years.

In addition, any property which is transferred to GovGuam must be remediated to the level which would allow the specified reuse of the property without exposing people involved in the reuse scenario to unacceptable health risks. This especially applies to the reuse of Waste Pile 7 if the property is ever reused for purposes which would require intrusive activities exposing people to the contaminants which are proposed to be covered at the site.

Response:

The selected alternative for Waste Pile 7 includes deed restrictions which preclude future use involving intrusive activities. Intrusive activities would re-open an exposure pathway and defeat the purpose of the soil cap. This is consistent with the OU 3 FFS, which had the concurrence of all of the RPM's and was finalized in January 1997. Some possible re-use scenarios may include a storage area or maintenance yard. In addition it will be noted that Site 20 is situated within an abandoned quarry with an average depth to the base of fill of 10.8 feet bgs. As such the land has limited future use regardless of whether the waste pile were removed.

Comment No. 8:

Page 3-19, Long-Term Monitoring. Appropriate monitoring wells should be monitored for contaminants which have been detected in soil contamination sites at MARBO OU, but which contaminated soils have not been removed from the site. Also, if contaminants associated with Air Force activities in the MARBO OU become detected in GovGuam Production wells through the Safe Drinking Water sampling requirements, the Air Force should implement a sampling program for those affected wells and assess possible remediation strategies through discussions by the RPMs. These details should be presented in the ROD.

Response: The groundwater alternative will be evaluated every five years as part of the CERCLA process. This includes all RPMs and interested parties. As part of the IRP the present long-term monitoring plan includes monitoring of the full suite of analytes for the wells in the vicinity of Site 20 (IRP-10, -15 and -16). The IRP will re-evaluate the long-term groundwater monitoring program every two years, also inclusive of RPMs.

Long-term monitoring requirements need to specifically address the cleanup goals of the selected remedy, and duration. Goals need to be defined in terms of contaminants levels and frequency of occurrence, as well as the efficiency of the natural attenuation process (please refer to Comment Number 6, above).

Response: The long term monitoring will continue until TCE/PCE concentrations are consistently below MCLs. This has been added to the text of the R.O.D.

Natural attenuation is also a process which occurs in the soil. At Waste Pile 7, organic contaminants which are proposed to be left in place at the site will experience a reduction in concentration over time due to natural degradation. The ROD should contain a description of the methodology to be used to document the natural attenuation process at Waste Pile 7.

Response: The intent of the cover is to reduce or mitigate exposure to the contaminants at Waste Pile 7 to within an acceptable health risk range, without the benefit of reduced soil concentrations. It is unlikely that natural attenuation will play a significant role in reducing the concentrations of the types of contaminants detected at Waste Pile 7. The contaminants of concern at Waste Pile 7 are pesticides and lead, both persistent, recalcitrant and relatively immobile.

Comment No. 9: **Page 3-33, Section 3.6. Please refer to the appropriate comments above.**

Response: Modifications have been made to Section 3.6 which include the five year CERCLA review, the two year Long Term Monitoring review, and a discussion on the parameters which will be assessed to determine the effectiveness of natural attenuation and the necessary length for long term monitoring (i.e., until TCE/PCE concentrations are consistently below MCLs).